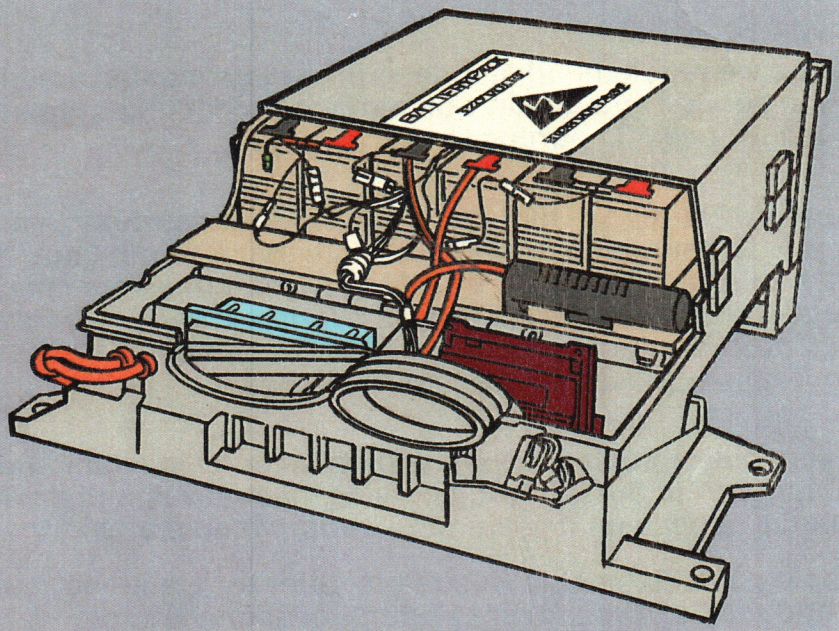
Chevrolet S10 Electric Battery Pack Service Certification

ALTERNATIVE GM FUELS



AUTHENTIC • TECHNICAL • SERVICE • INFORMATION

18005.02-1

Caution

In order to reduce the chance of personal injury and/or property damage, carefully observe the instructions that follow.

Service information provided by General Motors Corporation is intended for use by professional, qualified technicians. Attempting repairs or service without the appropriate training, tools, and equipment could cause injury to you and others. This could also damage the vehicle, or cause the vehicle to operate improperly.

Proper vehicle service and repair are important to the safety of the service technician and to the safe, reliable operation of all motor vehicles. If you need to replace a part, use the same part number or an equivalent part. Do not use a replacement part of lesser quality.

The service procedures we recommend and describe in this manual are effective methods of performing service and repair. Some of the procedures require the use of tools that are designed for specific purposes.

This manual may contain "Cautions" that you must observe carefully in order to reduce the risk of injury to yourself or others. This manual also contains "Notices" that must be carefully followed in order to avoid improper service that may damage the vehicle, or damage tools or equipment. These "Cautions" and "Notices" are not exhaustive. General Motors can not possibly warn of all the potentially hazardous consequences of your failure to follow these instructions.

If the vehicle being serviced is equipped with a Supplemental Inflatable Restraint (SIR), refer to the "Cautions" in the following service manual section/service category type before performing a service on or around SIR components or wiring:

- Section 9J — Supplemental Inflatable Restraints, refer to "Cautions" under "On-Vehicle Service" and the SIR Component Wiring Location view, or
- Service Category Type — Body and Accessories - Restraints, refer to "Cautions" under "On-Vehicle Service" and the SIR Component Wiring Location view

Failure to follow these "Cautions" could cause air bag deployment, personal injury, or otherwise unneeded SIR repairs.

In order to help avoid accidental air bag deployment and personal injury, whenever you service a vehicle that requires repair of the SIR and another vehicle system, we recommend that you first repair the SIR, then go on to the other system.

Chevrolet S10 Electric Battery Pack Service Certification

Foreword

This booklet contains information about the battery pack used in a General Motors vehicle, the Chevrolet S10 electric truck. Always refer to the applicable vehicle Service Manual and appropriate Dealer Technical Service Bulletins for additional information regarding system operation and diagnostic/repair procedures.

When this manual refers to a brand name, a number, or a specific tool, you may use an equivalent product in place of the recommended item.

All information, illustrations and specifications in this manual are based on the latest product information at the time of publication approval. General Motors reserves the right to make changes at any time without notice.

Published by NORTH AMERICAN OPERATIONS, General Motors Corporation, Warren, Michigan 48090-9008.

©1997 GENERAL MOTORS CORPORATION. ALL RIGHTS RESERVED. Information cut-off date 05-01-97.

PRINTED IN U.S.A.

No part of this book may be reproduced, stored in any retrieval system, or transmitted in any form or by any means (including but not limited to electronic, mechanical, photocopying, and recording) without prior written permission of General Motors Corporation. This applies to all text, illustrations, tables and charts.

Chevrolet S10 Electric Battery Pack Service Certification

Table of Contents

1. Introduction to the Battery Pack 1-1
   - Overview 1-1
   - Battery Pack Design 1-3
   - High Voltage Safety System 1-5
   - Battery Pack Control System 1-6

2. Battery Pack Design 2-1
   - Overview 2-1
   - Battery Module Design 2-2
     - Battery Capacity 2-3
     - Battery Pack Capacity (State of Charge) 2-4
   - Battery Pack Upper Level 2-5
   - Battery Pack Lower Level 2-7
   - Battery Pack High Voltage Circuits 2-9
   - Ventilation System 2-10
     - Air Distribution System 2-10
     - Vent System 2-12

3. High Voltage Safety System 3-1
   - Overview 3-1
   - Automatic High Voltage Disconnect System 3-2
     - High Voltage Interlock Loop (HVIL) 3-4
     - High Voltage Chassis Isolation 3-6
     - Automatic Disconnect and Battery Pack Control Module Communication 3-8
     - High Voltage Discharging Inside the Power Inverter Module 3-10
   - Pre-Charging (Pre-Conditioning) 3-11
   - Manual High Voltage Disconnect System 3-12

4. Battery Pack Control System 4-1
   - Overview 4-1
   - Battery Pack Control Module 4-3
     - Battery Module Voltage Monitoring 4-4
     - Total Battery Pack Voltage Monitoring 4-5
     - Battery Pack Current Flow Monitoring 4-6
     - Temperature Monitoring 4-7
   - Battery Pack Control Module Communication 4-8

Table of Contents

1. Introduction to the Battery Pack

Overview

The battery pack is the source of voltage for vehicle propulsion. The battery pack is located under the cargo bed of the Electric S10 (refer to Figure 1-1). The battery pack contains 26 individual battery modules (approximately 12 volts each) which provide approximately 320 volts total. The battery pack also contains a Battery Pack Control Module (BPCM) and Automatic Disconnect (AD) controller.

The BPCM is the main controller for battery pack operation, including charging. The BPCM uses several different communication circuits to exchange information with other control modules in the vehicle. The communication circuits include the following:

- Universal Asynchronous Receive and Transmit (UART) data line
- Class 2 data line
- Discrete communication lines

The AD controller is responsible for monitoring the integrity of the high voltage system outside of the battery pack. The AD controller also controls the two high voltage relays, called contactors. The contactors are used by the AD controller to disconnect the high voltage source in the battery pack from the high voltage systems outside of the battery pack.

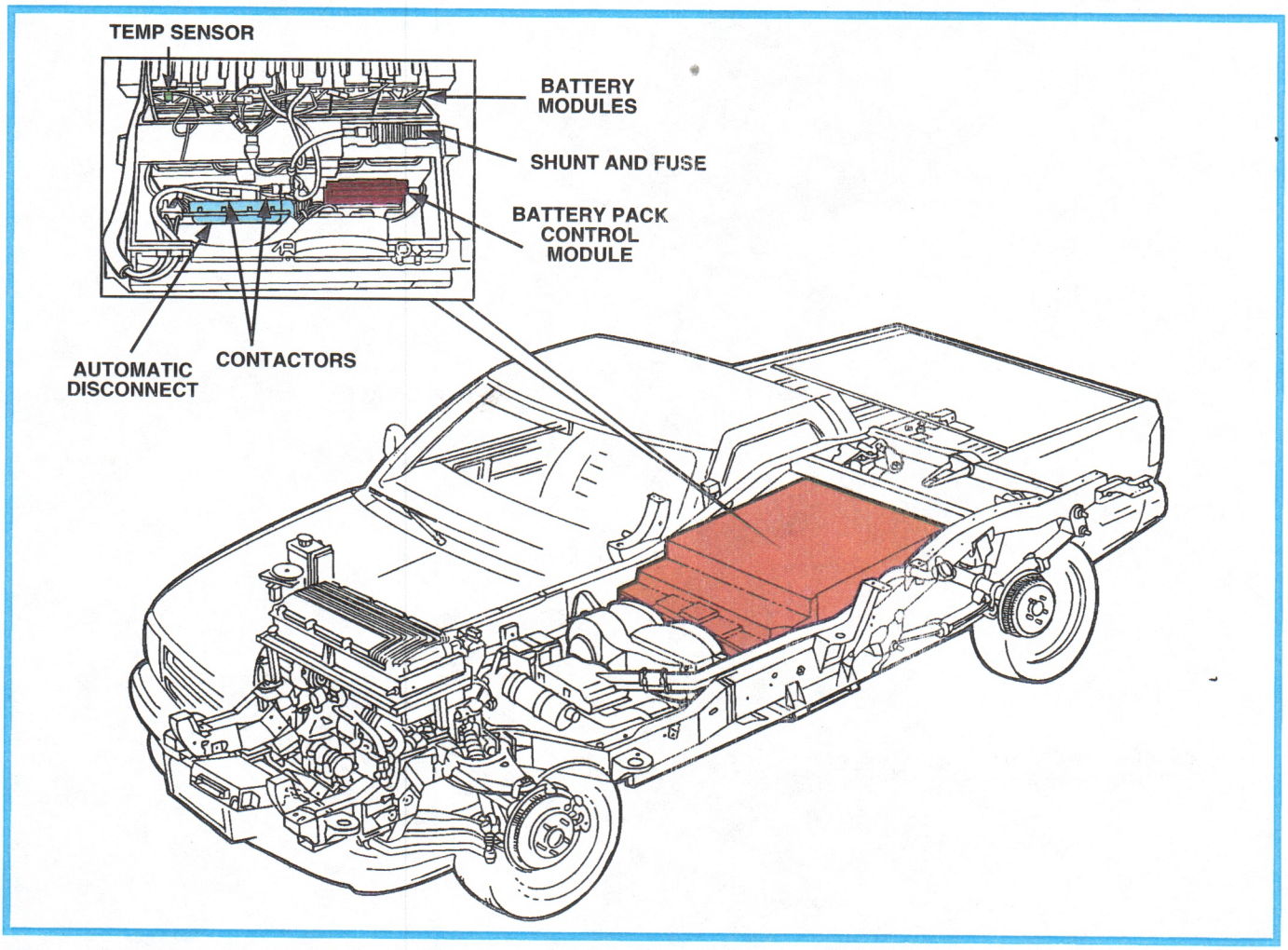


Figure 1-1, Battery Pack Location

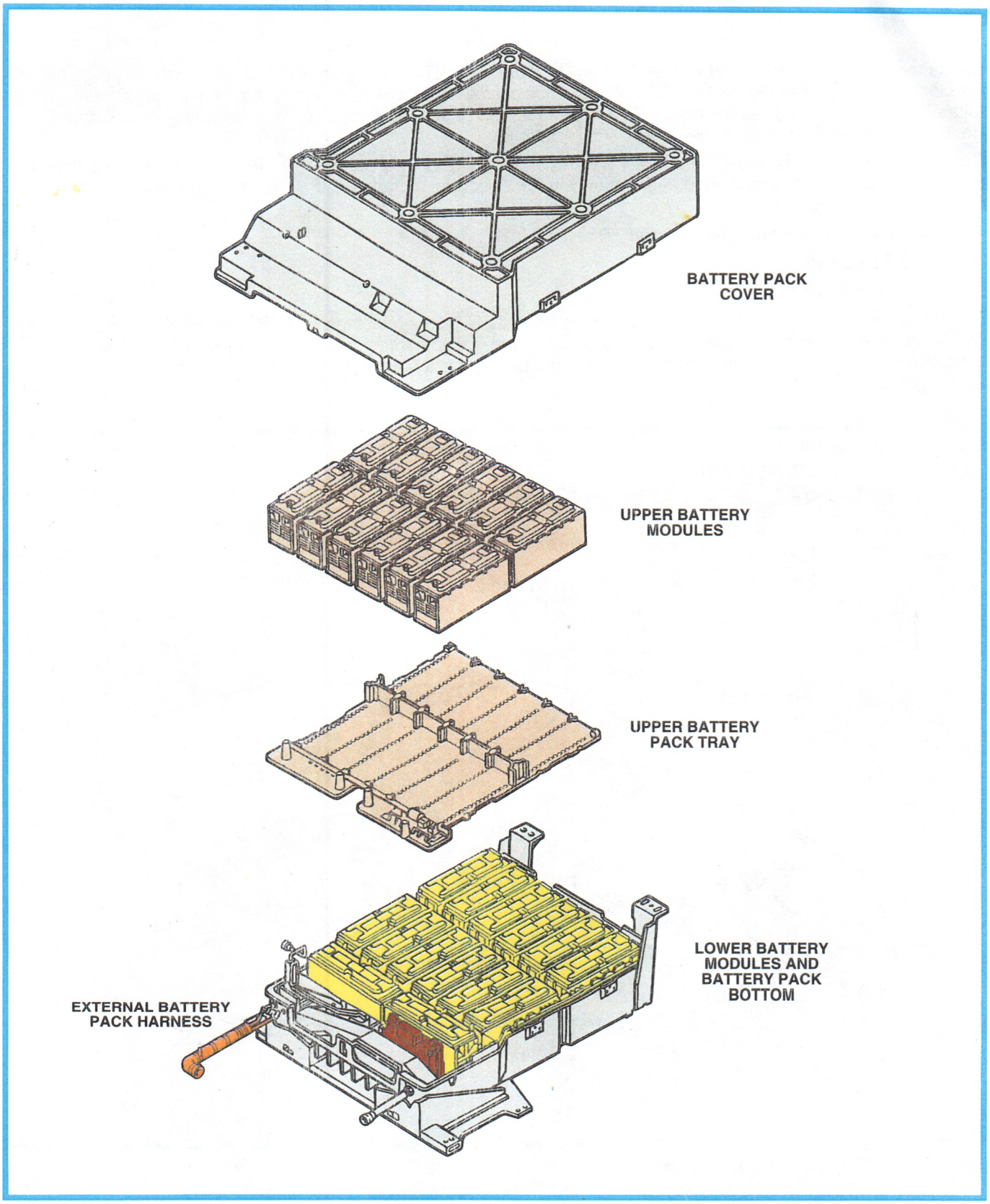


Figure 1-2, Battery Pack Design

Battery Pack Design

The 26 battery modules are arranged into two levels. The upper level contains 12 battery modules and the lower level contains 14 battery modules (refer to Figure 1-2). Each battery module has a potential of approximately 12 volts. The 26 battery modules are connected in series to provide approximately 320 volts total to the high voltage circuit. Each end of the battery module series circuit is connected to a contactor. The contactors are located underneath the Automatic Disconnect controller near the front of the battery pack (refer to Figure 1-3). The output side of each contactor is connected to a circuit of the external battery pack harness.

Connected to the front of the battery pack is the battery pack air distribution system. The air distribution system contains a fan and an exchanger. The air distribution system can provide the battery pack with ventilation, cooling or heating. The battery pack also has a vent system that connects to each battery module. The vent system allows battery module gases to exit the battery pack.

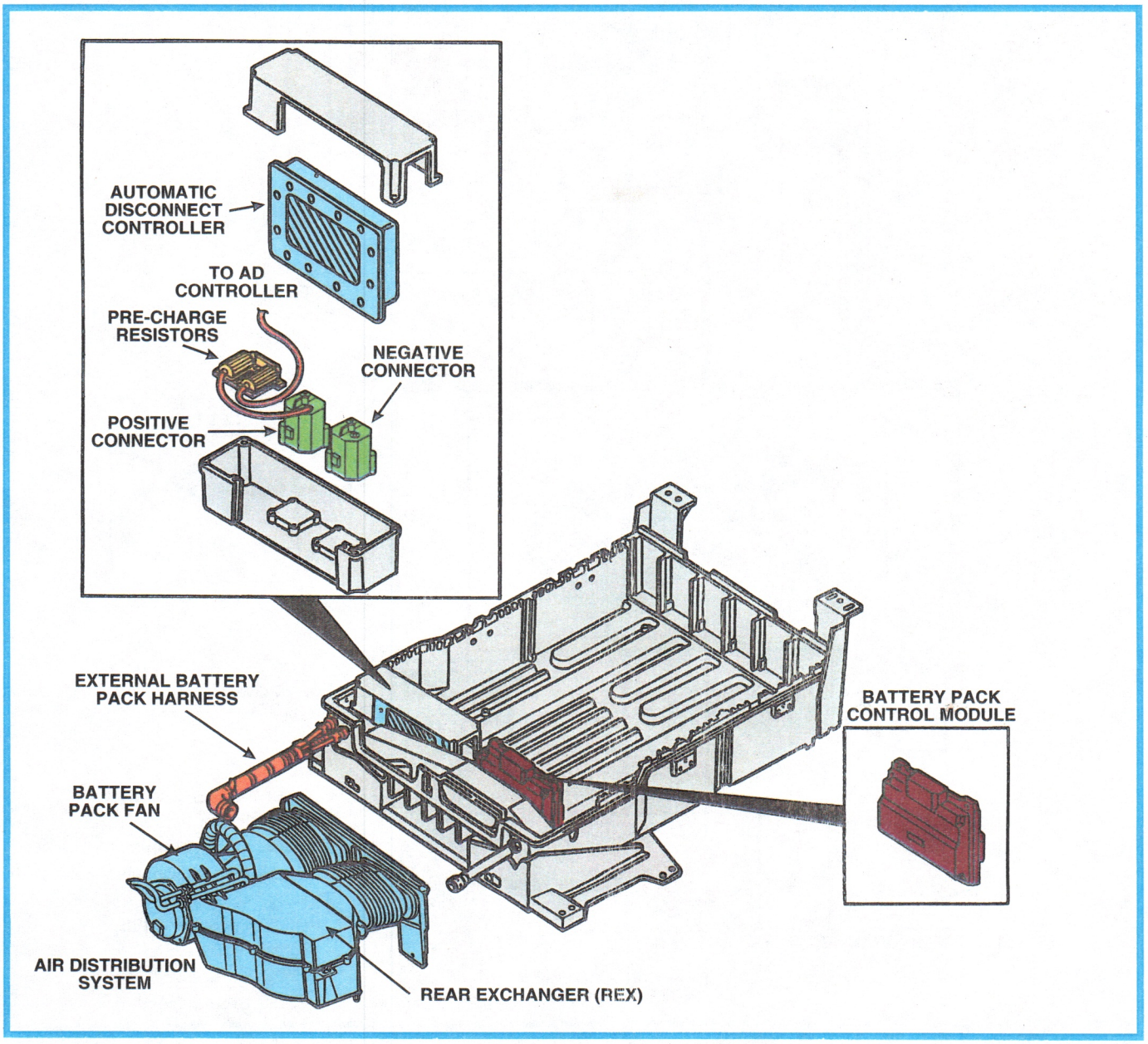


Figure 1-3, Contactor Location

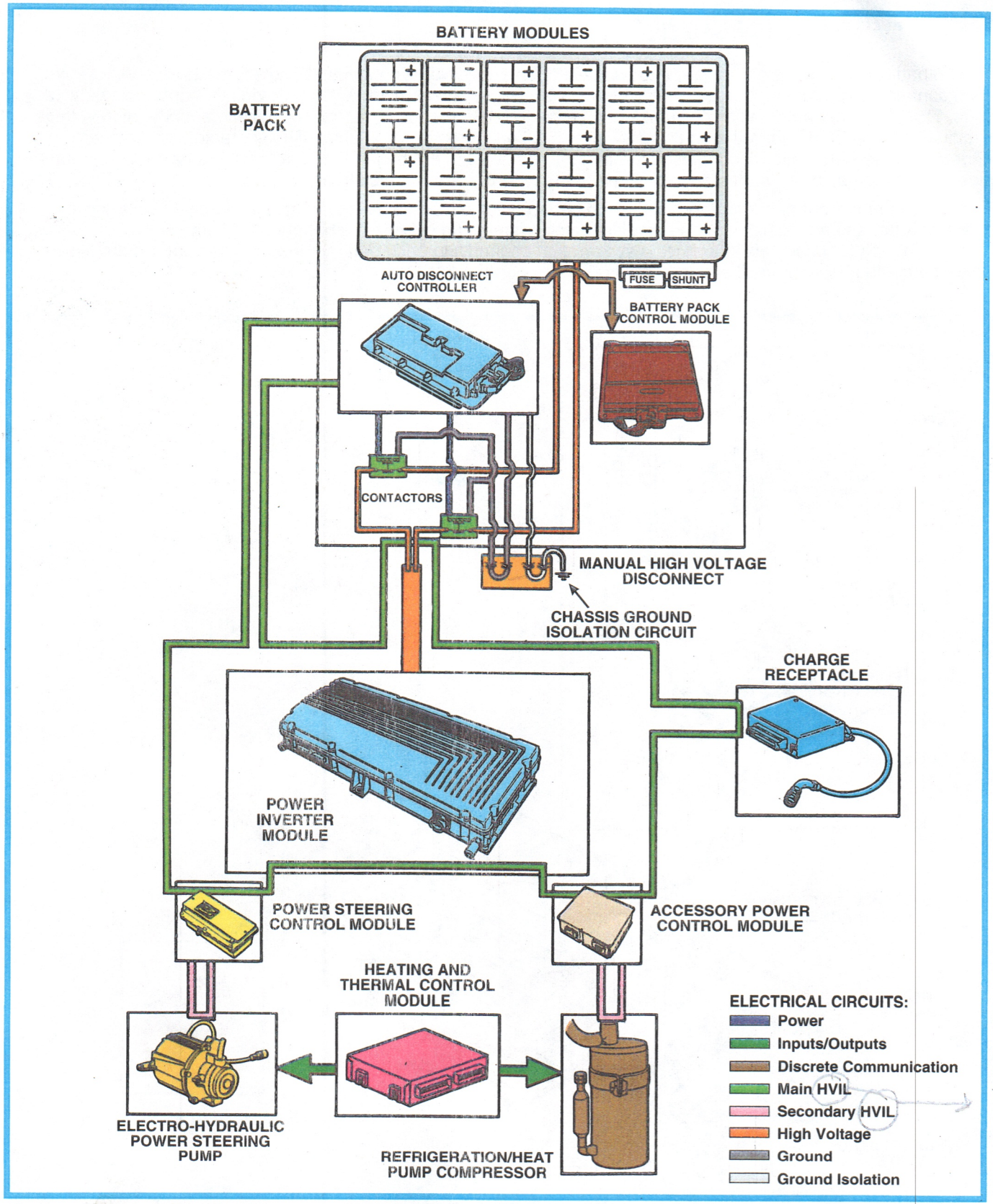


Figure 1-4, High Voltage Safety System Components

High Voltage Safety System

The high voltage safety system is responsible for monitoring the integrity of the high voltage system outside the battery pack. The primary controller for this system is the Automatic Disconnect (AD) controller. The AD controller monitors for disconnected high voltage connectors and monitors the vehicle chassis to determine if the high voltage circuit is shorted to the vehicle chassis. The AD controller uses the High Voltage Interlock Loop (HVIL) circuit and the chassis ground isolation circuit to perform this monitoring (refer to Figure 1-4).

The AD controller also controls the operation of the contactors. The AD controller will open the contactors for many high voltage system malfunctions.

The high voltage safety system also has a manual sub-system. This sub-system uses the manual high voltage disconnect to provide manual control of the contactors (refer to Figure 1-5). When the manual high voltage disconnect is removed, the contactors will open and the high voltage outside the battery pack will be discharged.

– CAUTION –

UNDER NORMAL OPERATING CONDITIONS, REMOVAL OF THE MANUAL HIGH VOLTAGE DISCONNECT CONNECTOR WILL CAUSE THE CONTACTORS TO OPEN. HOWEVER, IF THERE IS A MALFUNCTION IN THE CONTACTORS, HIGH VOLTAGE MAY BE PRESENT ON THE HIGH VOLTAGE CIRCUITS OUTSIDE OF THE BATTERY PACK. NEVER ASSUME THAT A HIGH VOLTAGE CIRCUIT IS "DEAD." ALWAYS USE A METER TO VERIFY THE STATUS OF A HIGH VOLTAGE CIRCUIT.

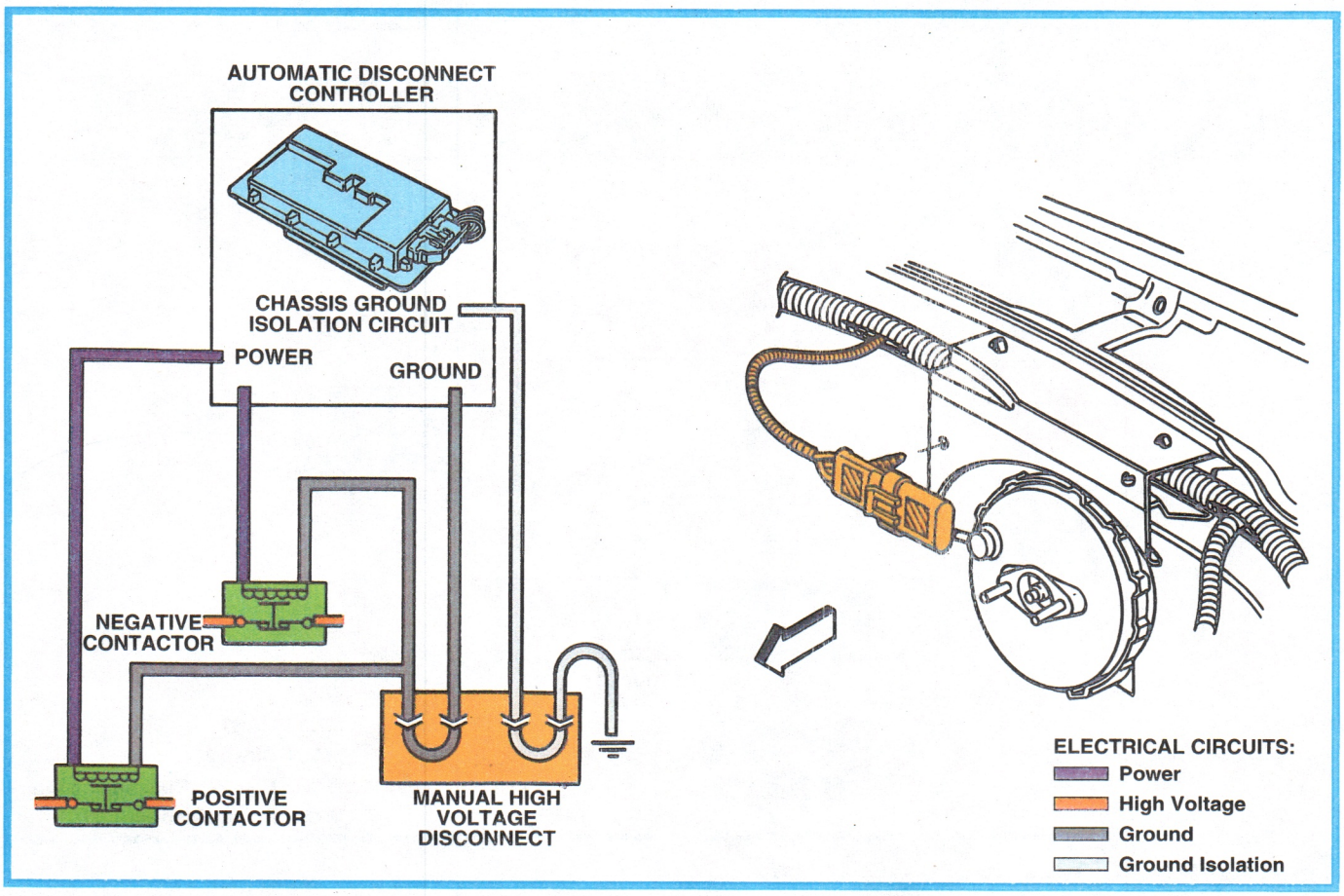


Figure 1-5, Manual Disconnect Location and Circuit

Battery Pack Control System

The primary controller of the battery pack is the Battery Pack Control Module (BPCM). The BPCM performs the following:

- Battery Module Voltage Monitoring
- Battery Pack Voltage Monitoring
- Battery Pack Current Flow Monitoring
- Battery Pack Temperature Monitoring

The BPCM uses this information to isolate malfunctions and to calculate the State-Of-Charge (SOC) of the battery pack. The SOC is an indication of the available range of the vehicle and also the charge status of the battery pack. This information is provided to other control modules on the communication data lines (refer to Figure 1-6). The BPCM also uses these data lines to request the following actions:

- Propulsion Disable (to the Power Inverter Module)
- Battery Pack Thermal Management (to the Heating and Thermal Control Module)
- Contactor Command (to the AD controller)
- Gauge and Lamp Control (to the Body Control Interface Module and Power Inverter Module)
- Charging Rate (to the Charge Receptacle)

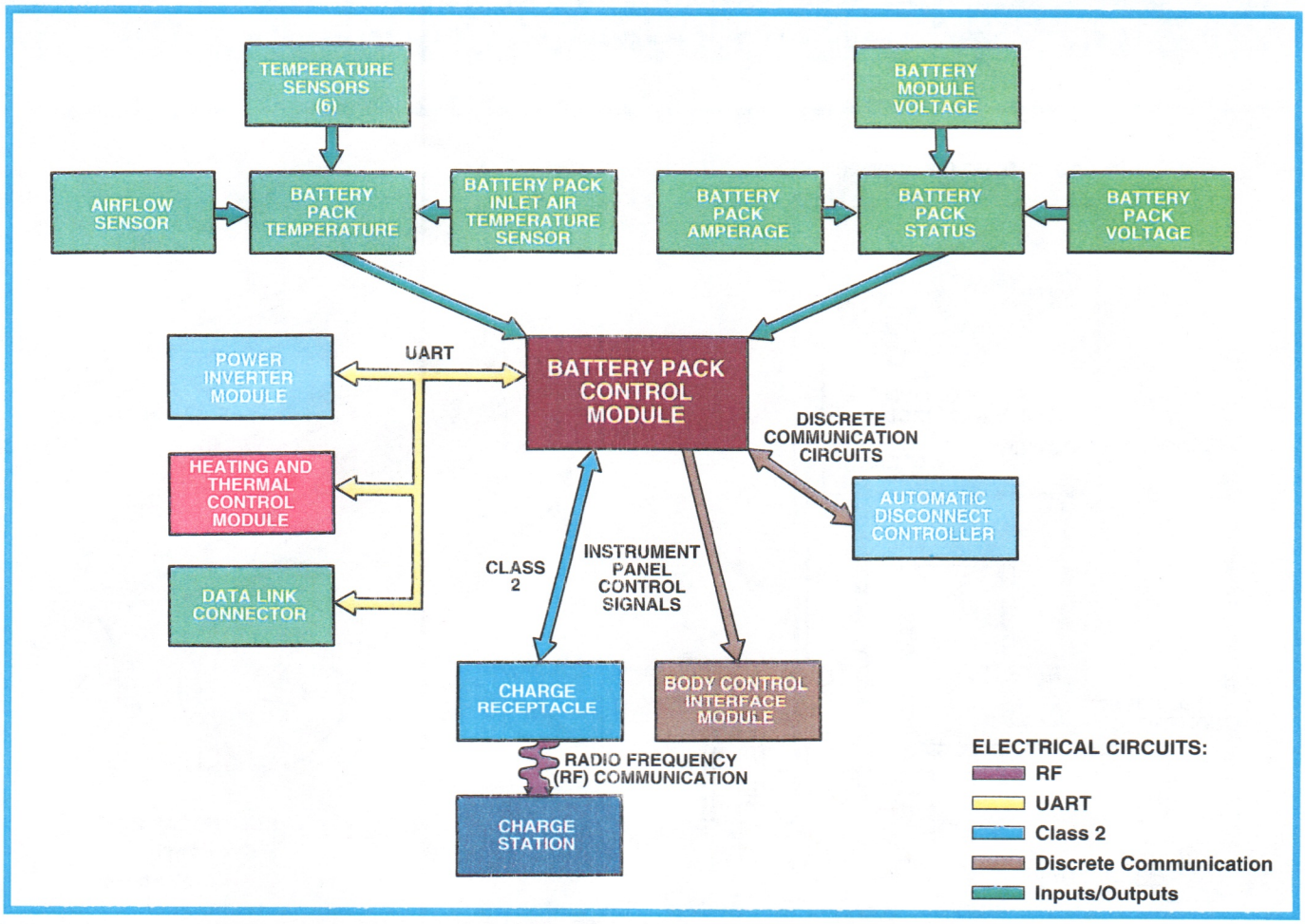


Figure 1-6, Communication Data Lines

2. Battery Pack Design

Overview

The Battery Pack has the following components:

- 26 Battery Modules split into two levels
- Battery Pack Control Module (BPCM)
- Automatic Disconnect Controller
- Contactors (2)
- Pre-Charge Resistors
- Shunt and Fuse
- Ventilation System

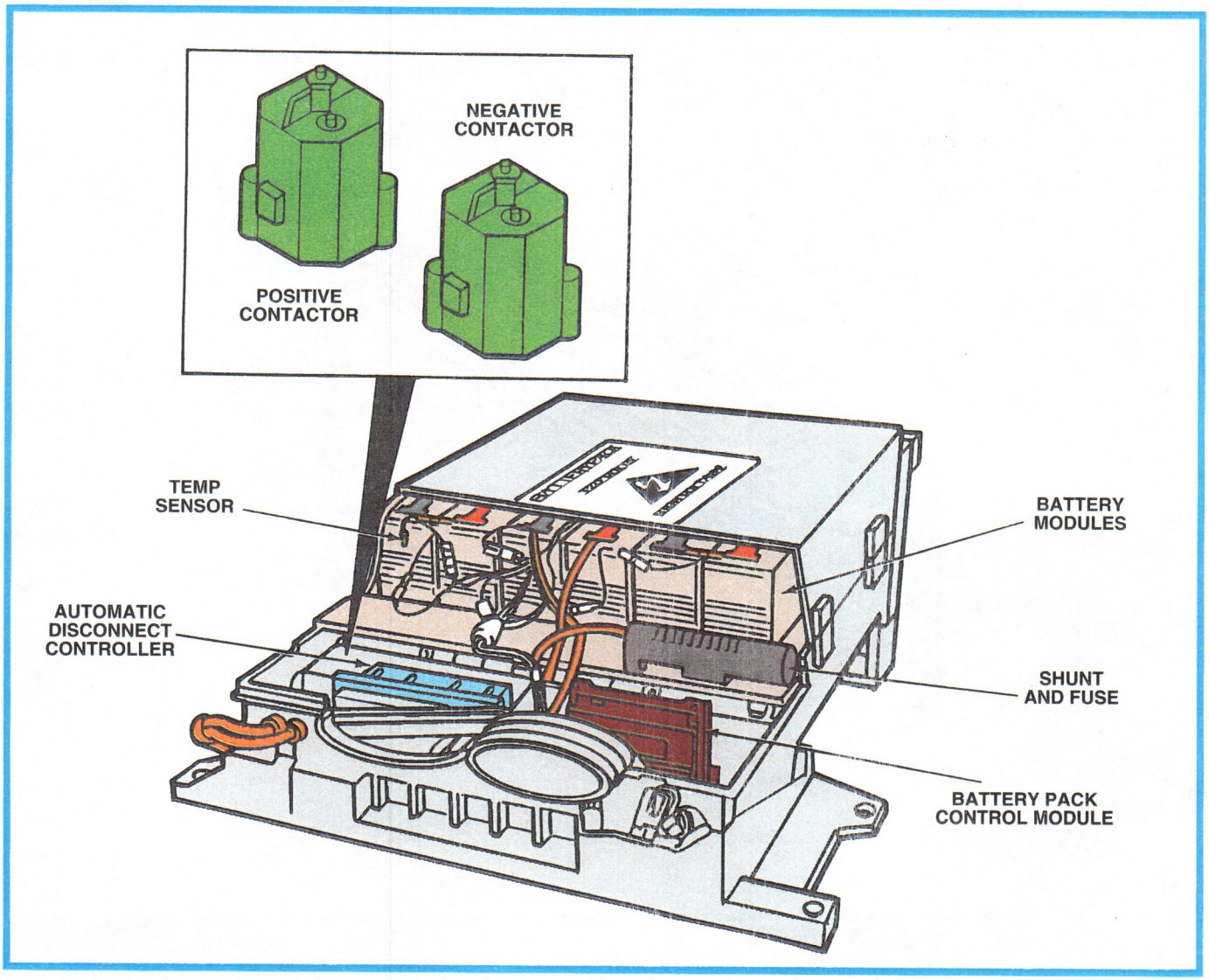


Figure 2-1, Battery Pack Cut-Away

Battery Module Design

The battery pack has 26 battery modules. The battery modules are 12-volt lead acid batteries. The battery modules are designed with six two-volt cells (refer to Figure 2-2). Each cell has a positive and negative lead plate coated with a lead sulfate paste. The lead plates are separated by a glass matte that is saturated with a sulfuric acid electrolyte.

The glass matte design requires very little electrolyte. If all battery modules were ruptured during a collision, the amount of electrolyte that would be released is less than one cup. Since there is very little electrolyte within the battery modules, the battery modules are equipped with valves to prevent electrolyte evaporation. These valves allow gases to exit the battery module but do not allow the electrolyte to exit the battery module.

During discharge, a chemical reaction occurs between the lead plates and the sulfuric acid. The chemical reaction produces lead sulfate and water. As the reaction occurs, the voltage of the battery module decreases. Battery module voltage normally ranges from 11 to 14 volts. If the battery module consistently operates at voltages lower than 10.5 volts, the chemical reaction inside the battery module will create a build-up on the lead plates and reduce the capacity of the battery module.

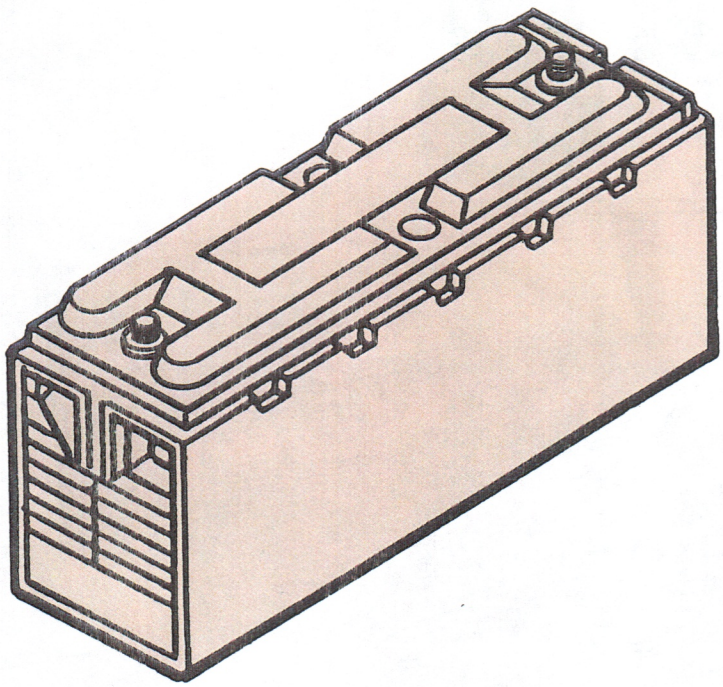


Figure 2-2, Battery Module

Battery Capacity

Battery capacity is the amount of energy the battery module can deliver at a given voltage. Capacity is measured in amp-hours. An amp-hour is the amount of amperage the battery module can deliver over a period of time. The battery modules typically have a capacity of 48 amp-hours when new. This capacity can increase to approximately 52 amp-hours in the first 100 to 200 charge/discharge cycles. The capacity will then gradually decrease until the capacity no longer meets the needs of the vehicle operator.

Battery Module capacity is affected by the following conditions:

- Battery Design
- Temperature
- Discharge Rate
- Battery Age

The design of the battery module establishes the battery capacity. The amount of active material inside the battery module will determine the potential capacity. The battery modules in the battery pack will not all have the same potential capacity. The active material in each battery module will not be the same due to the manufacturing process.

During normal operation, the temperature of the battery module has the greatest affect on capacity. At warmer temperatures, the battery electrolyte is more conducive to the chemical reaction, and the capacity will be at its normal state. Warm temperatures are typically better for battery module capacity. However, temperatures exceeding 140°F (60°C) can increase battery corrosion and adversely impact the life span of the battery.

Cold temperatures greatly impact battery capacity. Cold temperatures can reduce battery capacity to half the normal capacity. The loss of capacity due to cold temperature is only temporary. When the temperature of the battery is increased, the capacity will increase.

The rate of discharge can also affect the capacity of a battery module. A slower discharge rate will allow the material in the battery module to stay active longer. A high rate of discharge will prevent some material from reacting and will reduce the overall capacity of the battery module.

The battery age has a large affect on the battery module capacity. The normal chemical process that occurs in a battery during use will over time break down the chemicals. This reduces the amount of active material inside the battery module. As the active material is reduced, the capacity of the battery will decrease.

2. Battery Pack Design

Battery Pack Capacity (State-of-Charge)

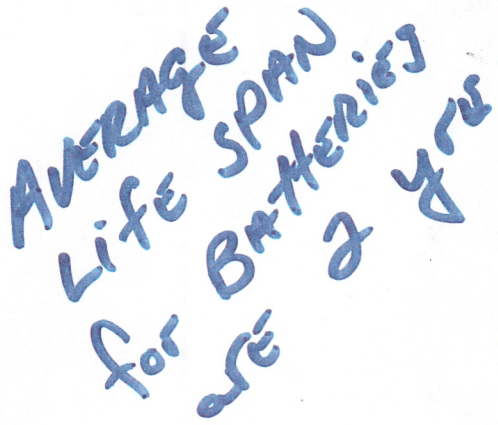
The capacity of the battery pack is dependent on the state of the individual battery modules. Since the battery modules are connected in series, the battery pack capacity will be limited by the weakest battery module. If the weakest battery module is only capable of providing 38 amp-hours, the battery pack will only be able to provide 38 amp-hours of service.

The capacity of the battery pack has a direct effect on the state-of-charge of the battery pack. The State-Of-Charge (SOC) is a value the Battery Pack Control Module (BPCM) calculates to determine the approximate range and power level of the battery pack. The SOC is displayed on the instrument panel gauge. This provides the vehicle operator with an indication of the available vehicle range. After charging, the gauge should display 100% SOC. The rate at which the SOC decreases is greatly affected by the battery pack capacity. If the capacity of the battery pack is reduced due to age, temperature or discharge rate, the state-of-charge will decrease more rapidly.

The SOC displayed on the gauge is called the User State-of-Charge (USOC). The USOC is 15% lower than the true SOC. This is to prevent the vehicle operator from discharging the battery pack to a point where capacity could be permanently affected.

The following are conditions that will affect the state-of charge of the battery pack:

- Average Battery Pack temperature
- Lowest Battery Module voltage and current
- Battery Pack voltage
- Amp-hours lost due to parasitic discharge
- Amp-hours lost due to battery pack self discharge
- Age of the battery modules
- Amp-hours used
- Average current usage
- Battery Pack capacity
- Battery Pack capability



Battery Pack Upper Level

The upper level of the battery pack contains the following components (refer to Figure 2-3):

- 12 Battery Modules
- Shunt and Fuse
- Temperature Sensors
- Battery Module Sense Circuits

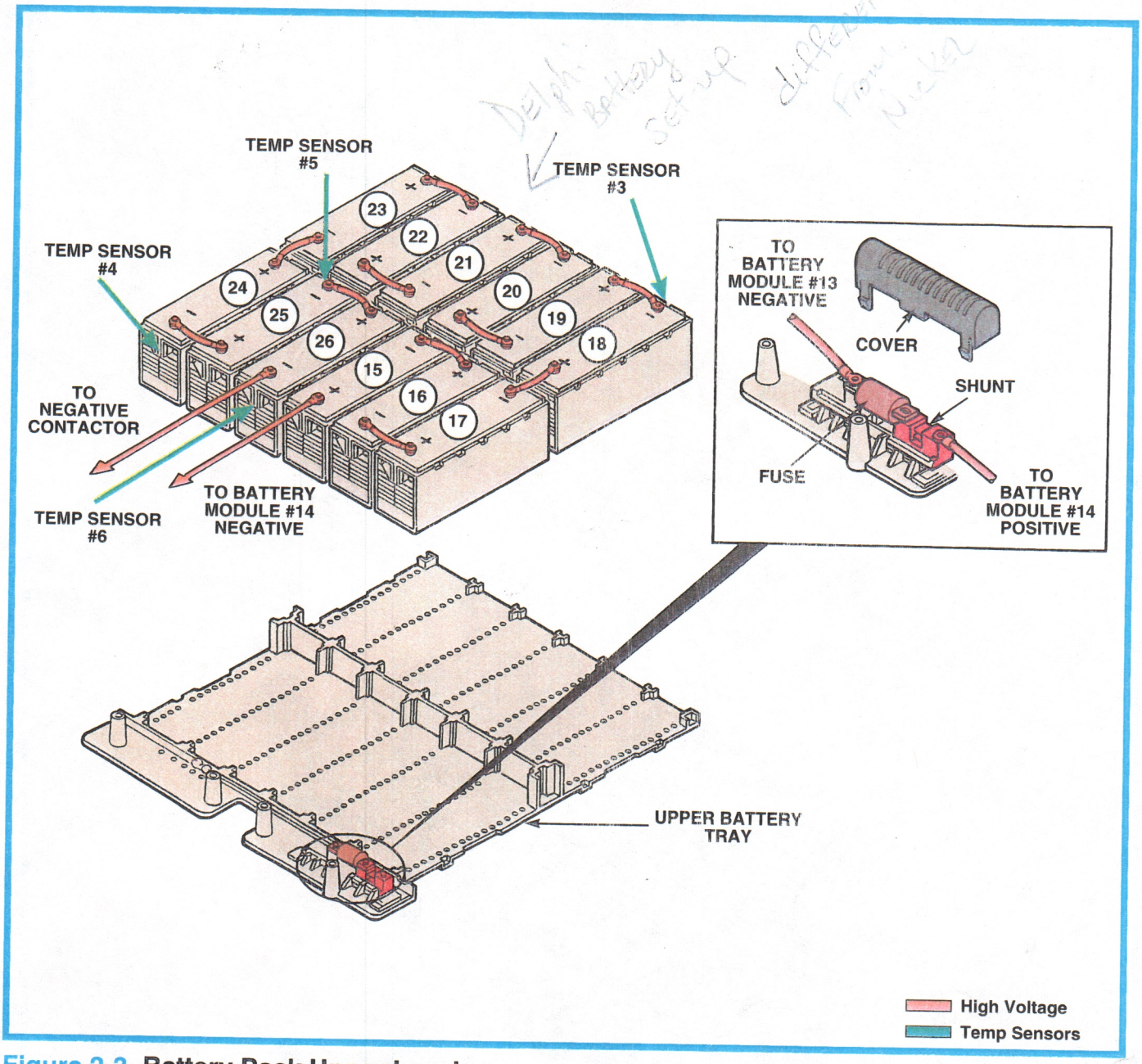


Figure 2-3, Battery Pack Upper Level

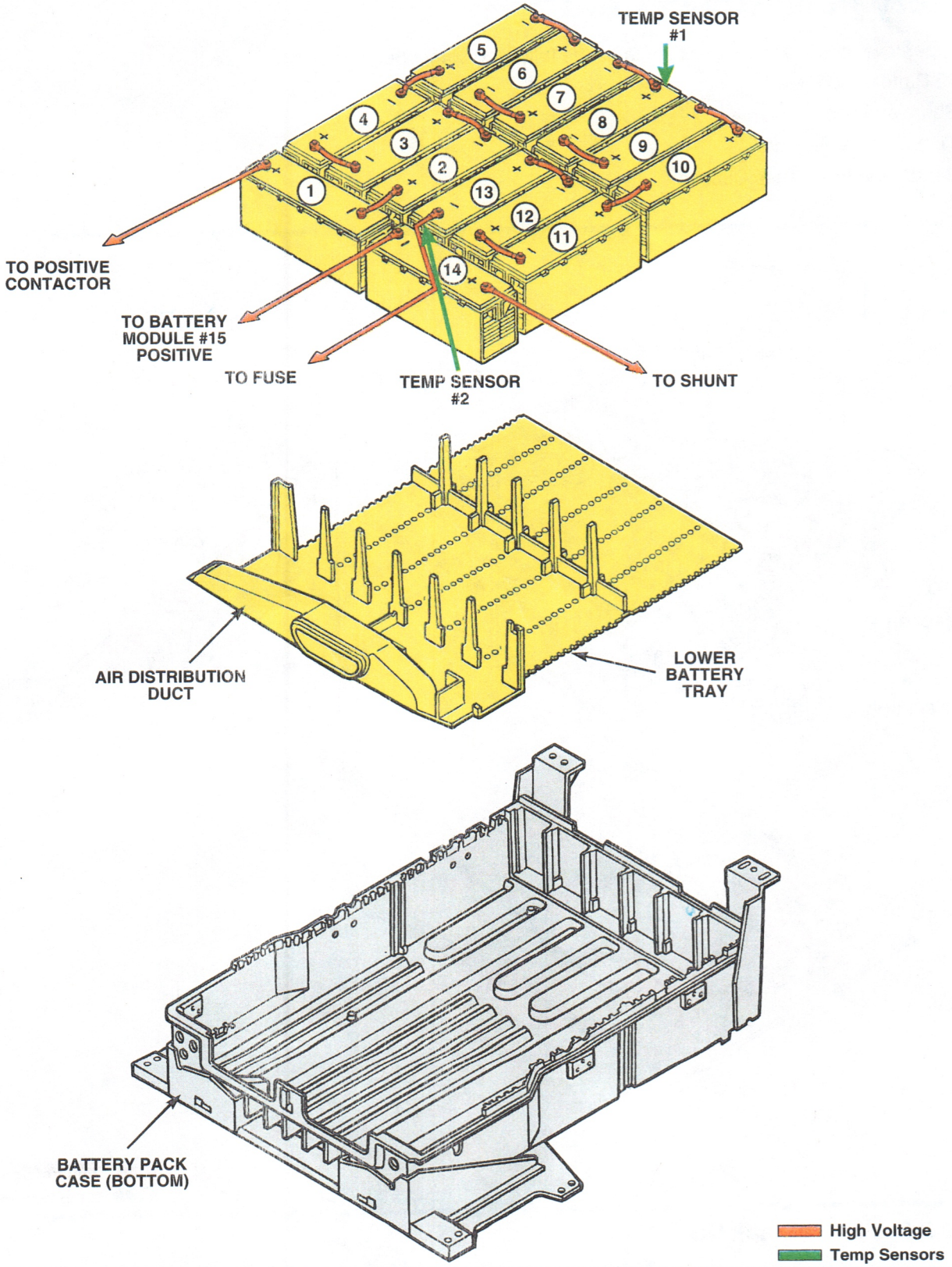


Figure 2-4, Battery Pack Lower Level

Battery Pack Lower Level

The lower level of the battery pack contains the following components (refer to Figures 2-4 and 2-5):

- 14 Battery Modules
- Automatic Disconnect Controller
- Contactors
- Battery Pack Control Module
- Pre-Charge Resistors
- Temperature Sensors
- Battery Module Sense Circuits

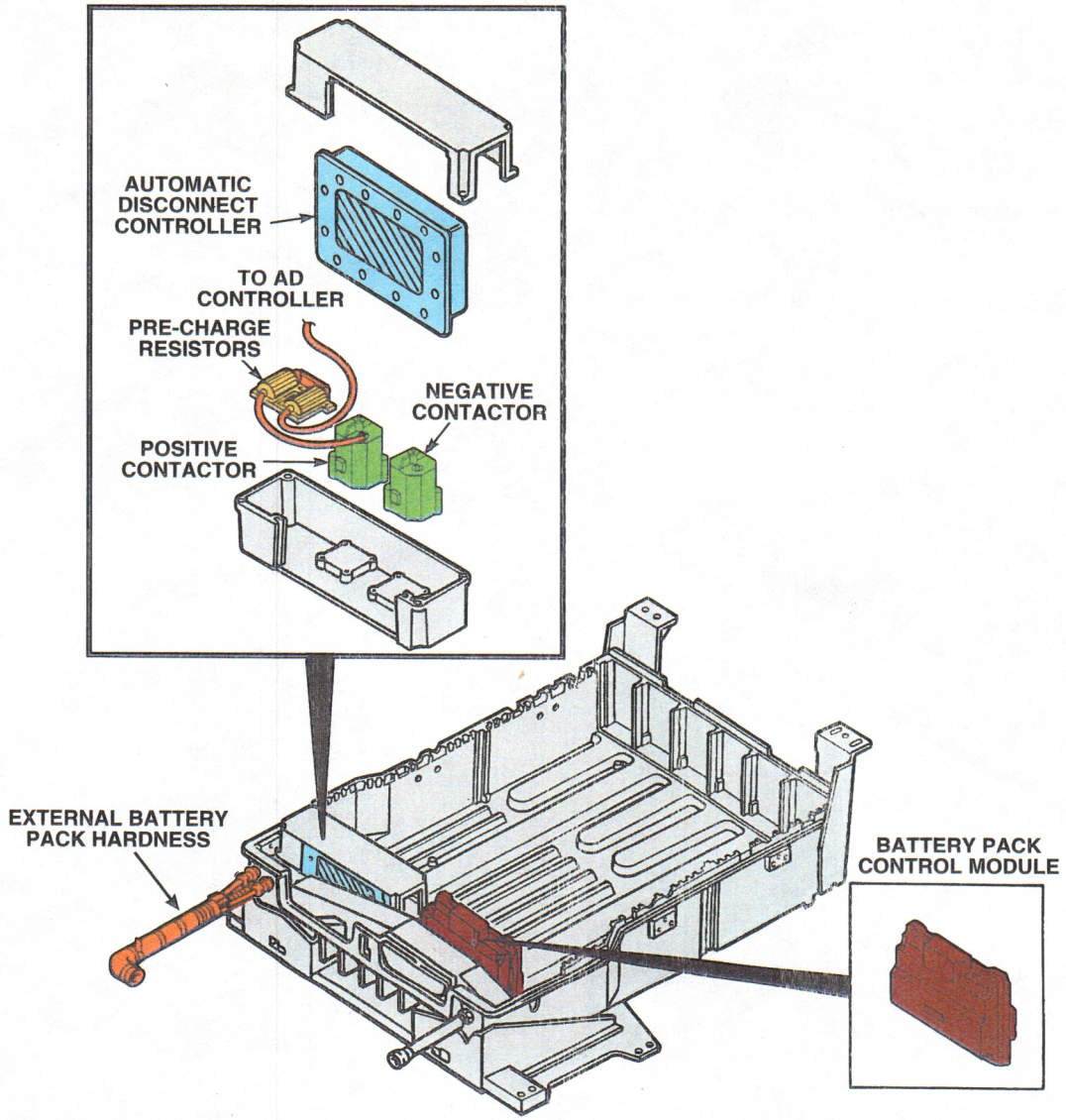


Figure 2-5, Battery Pack Lower Level

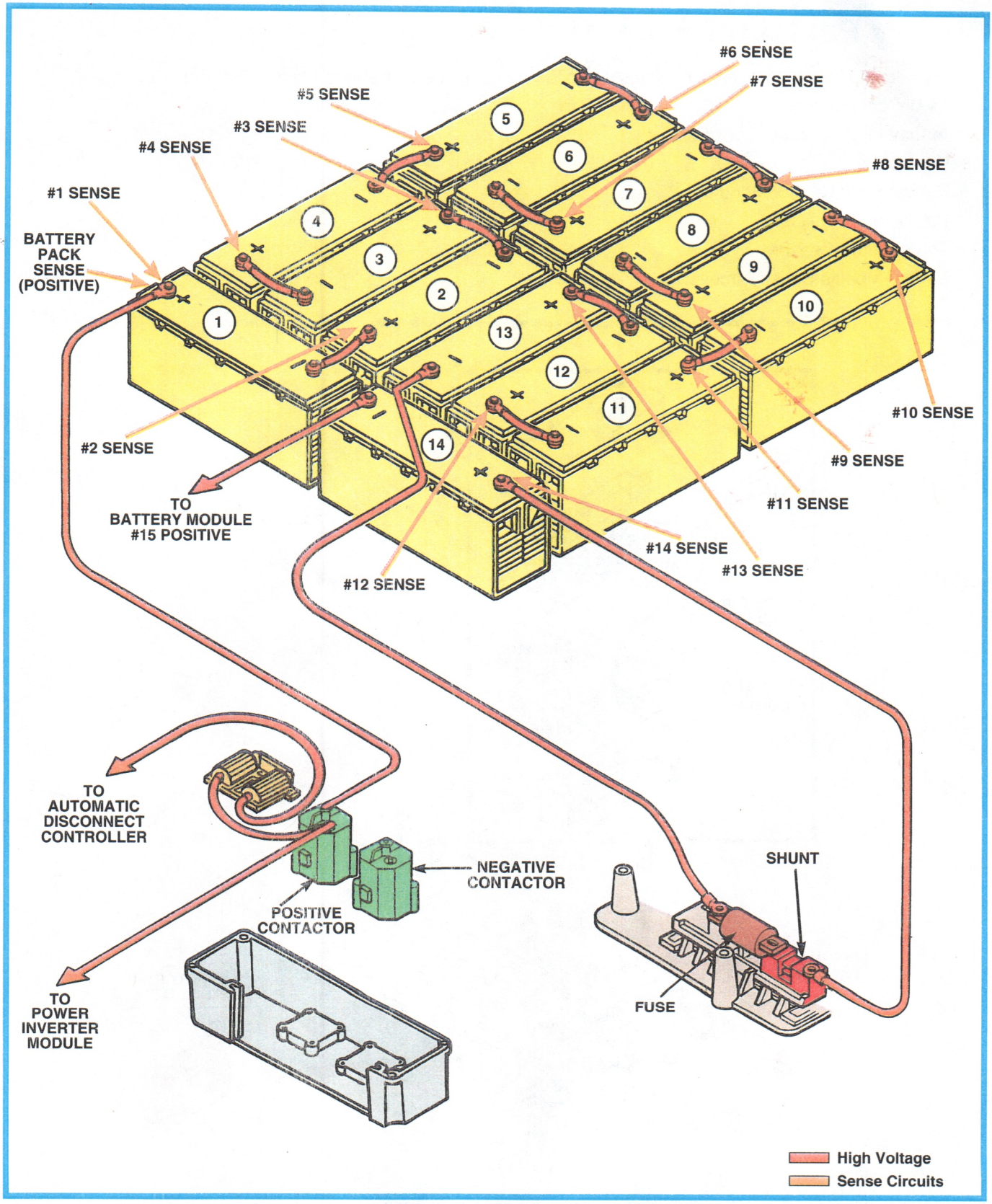


Figure 2-6, Battery Pack Lower Level (High Voltage Circuits)

Battery Pack High Voltage Circuits

The high voltage inside the battery pack is conducted through a series circuit. The 26 battery modules are connected in series (refer to Figures 2-6 and 2-7). A shunt and fuse are located in the middle of the battery pack series circuit between battery modules 13 and 14. The contactors are connected to the negative and positive ends of the battery pack series circuit. The sense circuits connected to the battery modules also have high voltage. However, the current through the circuit is limited by a [illegible] ohm resistor located near the battery module terminal.

– CAUTION –

THE CONTACTORS HAVE EXPOSED TERMINALS. TAKE PRECAUTIONS NOT TO SHORT ACROSS THE TERMINALS OF THE TWO CONTACTORS. THE CONTACTORS HAVE A 320 VOLT POTENTIAL AND CAN CAUSE FATAL INJURY IF THE TERMINALS OF THE TWO CONTACTORS ARE SHORTED TOGETHER.

The pre-charge resistors are also part of the high voltage series circuit. The pre-charge resistors are connected across the contacts of the positive contactor. The circuit is controlled by a switch inside the Automatic Disconnect controller. Current only flows through the pre-charge resistors during pre-charging; however, there is a high voltage potential in this circuit during normal operation.

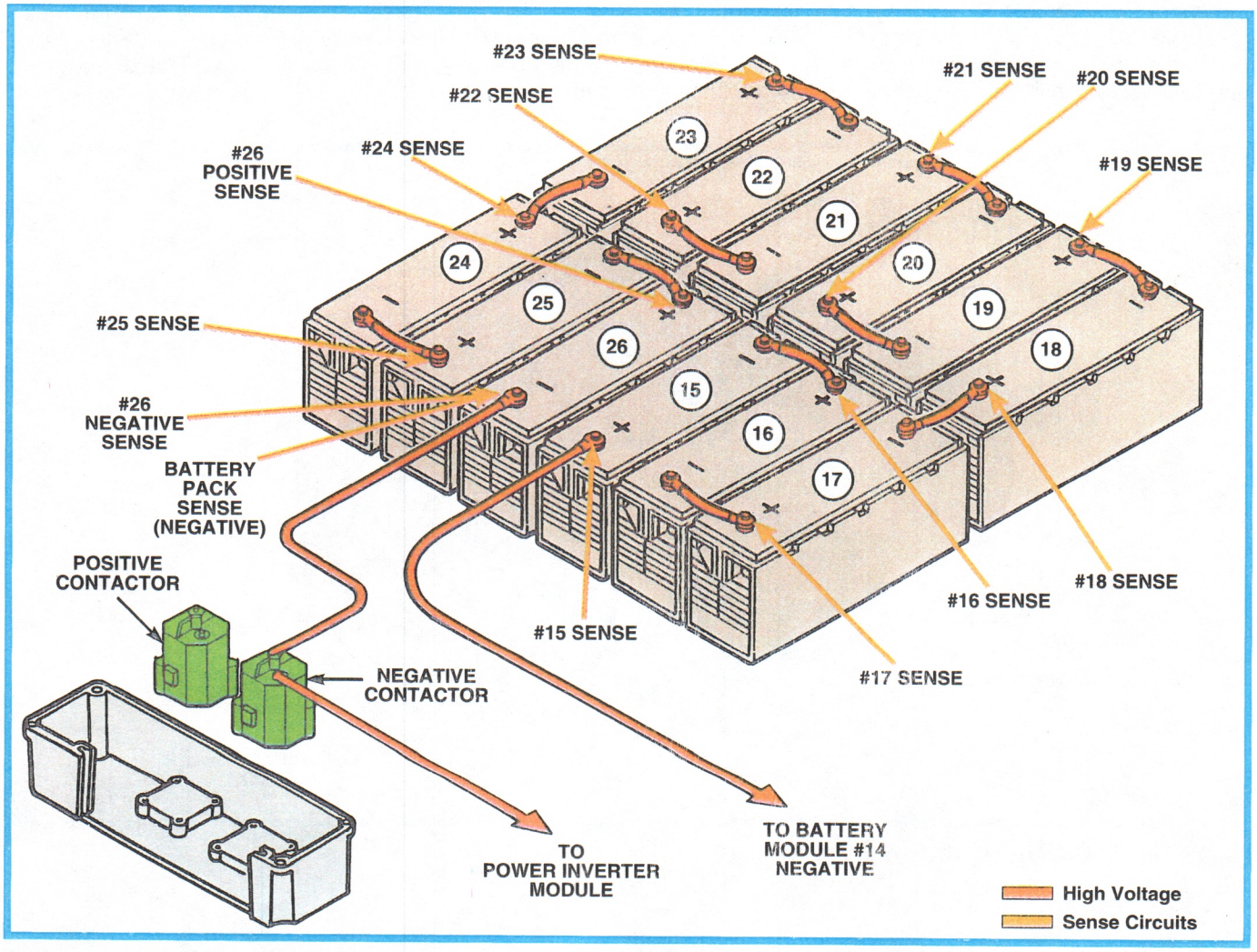


Figure 2-7, Battery Pack Upper Level (High Voltage Circuits)

Ventilation System

The ventilation system has two sub-systems:

- Air Distribution System
- Vent System

Air Distribution System

The air distribution system has the following components (refer to Figure 2-8):

- Battery Pack Air Flow Sensor
- Battery Pack Fan
- Rear EXchanger (REX)
- Battery Pack Inlet Air Temperature (BPIAT) Sensor
- Air Distribution Ducts
- Internal Air Flow Path

The air distribution system is used to ventilate the battery pack. The air distribution system uses a fan to circulate air through the battery pack. Air flow through the battery pack is directed through the lower level of the battery pack to the upper level (refer to Figure 2-9). A small amount of outside air is allowed to bleed into the battery pack through an outside air duct. Air is allowed to slowly exit the battery pack through the small white disks on the battery pack cover. The air distribution system ventilates the battery pack during propulsion to remove any residual battery gases and to provide passive cooling of the battery modules and control modules.

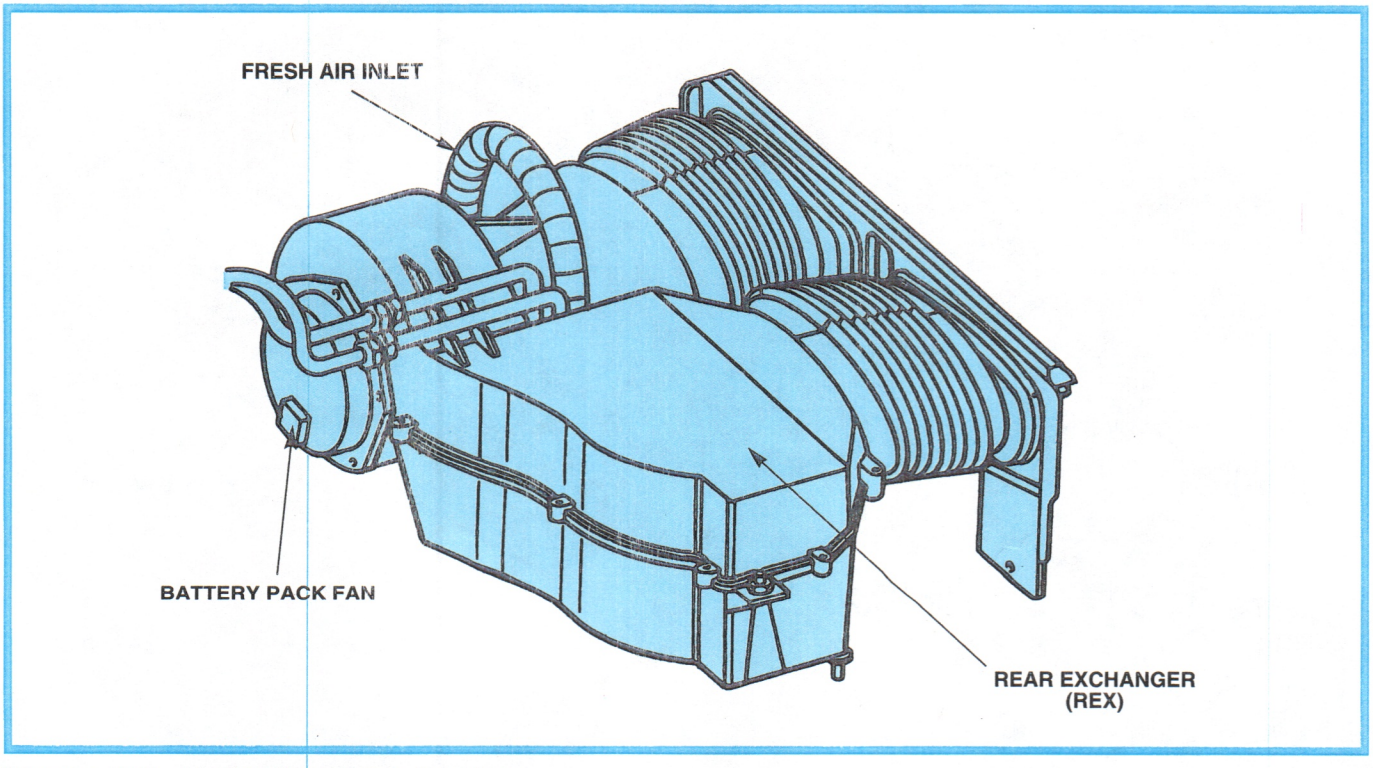


Figure 2-8, Air Distribution System

The BPCM uses the battery pack air flow sensor to monitor the operation of the air distribution system. During normal operation, the resistance of the sensor will change based on the air flow through the battery pack. The BPCM can determine certain malfunctions based on the feedback from the sensor. If the sensor indicates no air flow when the BPCM commands air flow, the BPCM will set a DTC.

The air distribution system can also provide heating or cooling of the battery pack. The BPCM determines the need for thermal management based on the BPIAT sensor and the six temperature sensors located in the battery pack. The REX can heat or cool the air entering the battery pack when commanded by the BPCM. The REX is part of the Refrigeration/Heat Pump (R/HP) system. The R/HP system is controlled by the Heating and Thermal Control Module (HTCM).

The BPCM can command cooling during propulsion or charging. The BPCM can only command heating during charging.

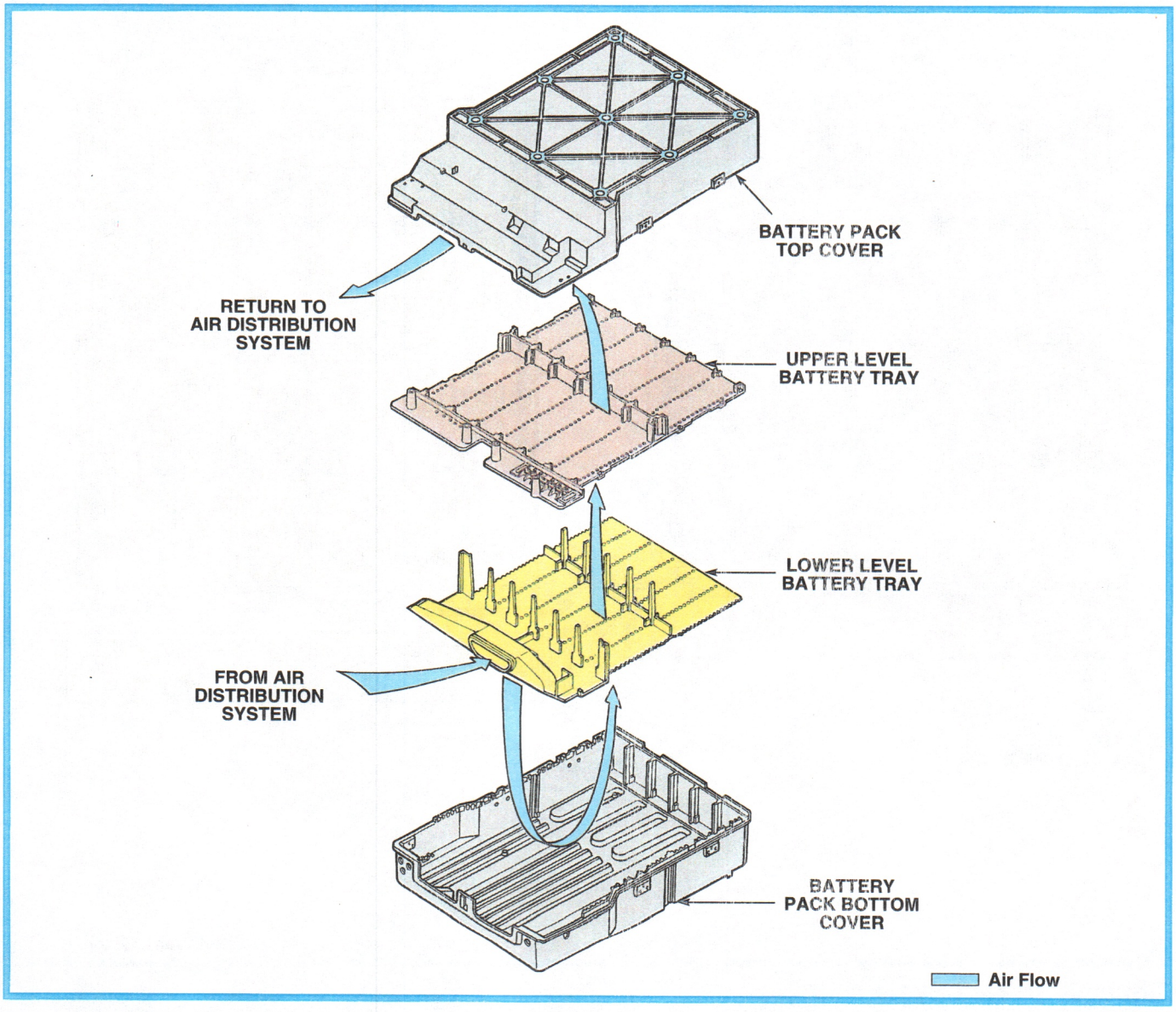


Figure 2-9, Air Flow Through The Battery Pack

Vent System

The vent system is used to connect the vents of the individual battery modules. There are two vent systems. One vent system connects the battery modules on the upper level. The second vent system connects the battery modules on the lower level. The vent system is used to direct battery module gases outside of the battery pack. The vent systems are connected to an external vent located on the left side of the battery pack near the Automatic Disconnect controller.

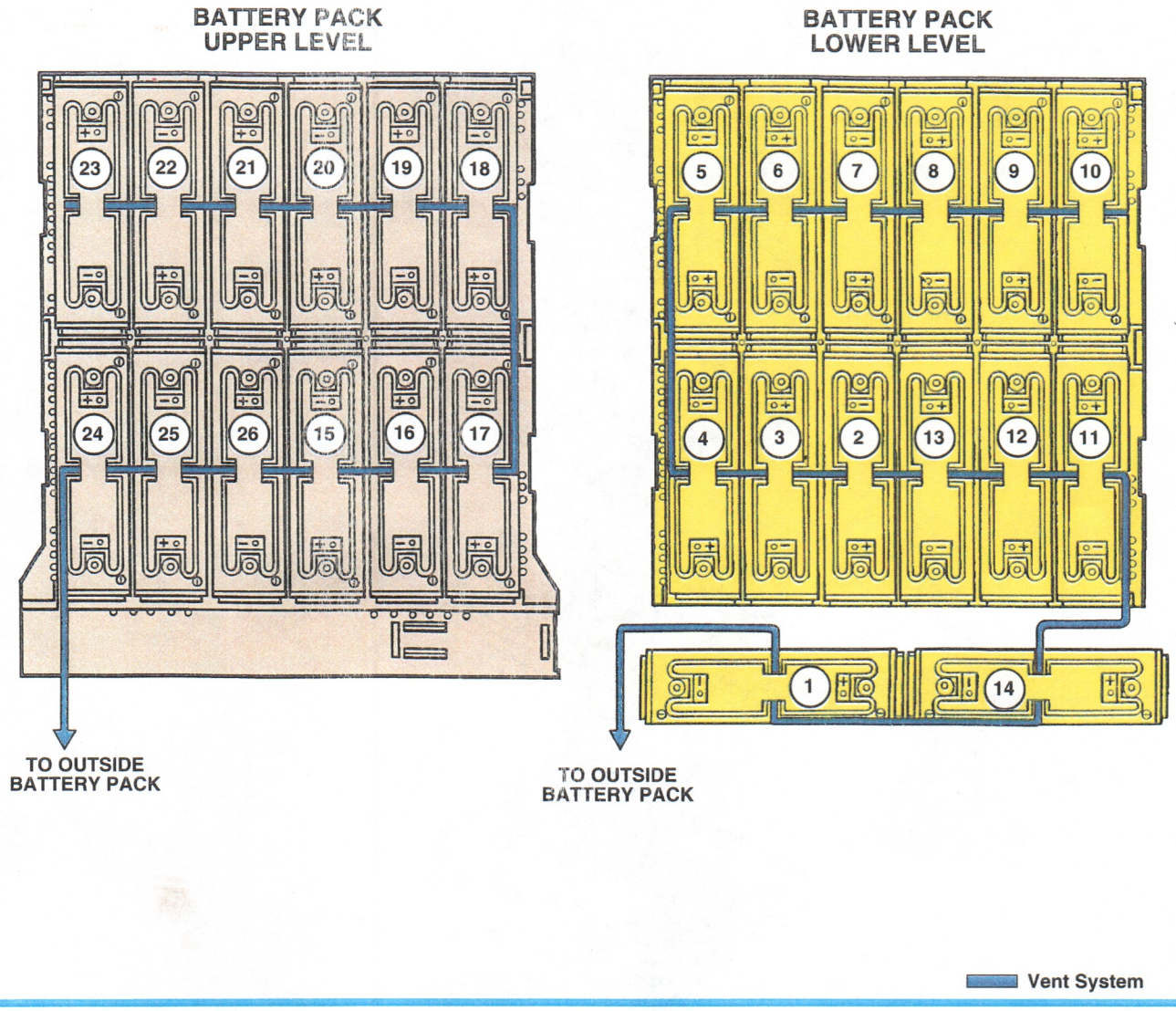


Figure 2-10, Vent System

Notes

Notes

3. High Voltage Safety System

Overview

The high voltage safety system has the following components (refer to Figure 3-1):

- Automatic Disconnect Controller
- Battery Pack Control Module (BPCM)
- Power Inverter Module (PIM)
- Heating and Thermal Control Module (HTCM)
- Manual High Voltage Disconnect
- Contactors (2)
- High Voltage Interlock Loop (HVIL) Circuits

The high voltage safety system is divided into the following sub-systems:

- Automatic High Voltage Disconnect System
- Manual High Voltage Disconnect System

The high voltage safety system is also responsible for pre-charging (pre-conditioning) the high voltage bus after the contactors are opened.

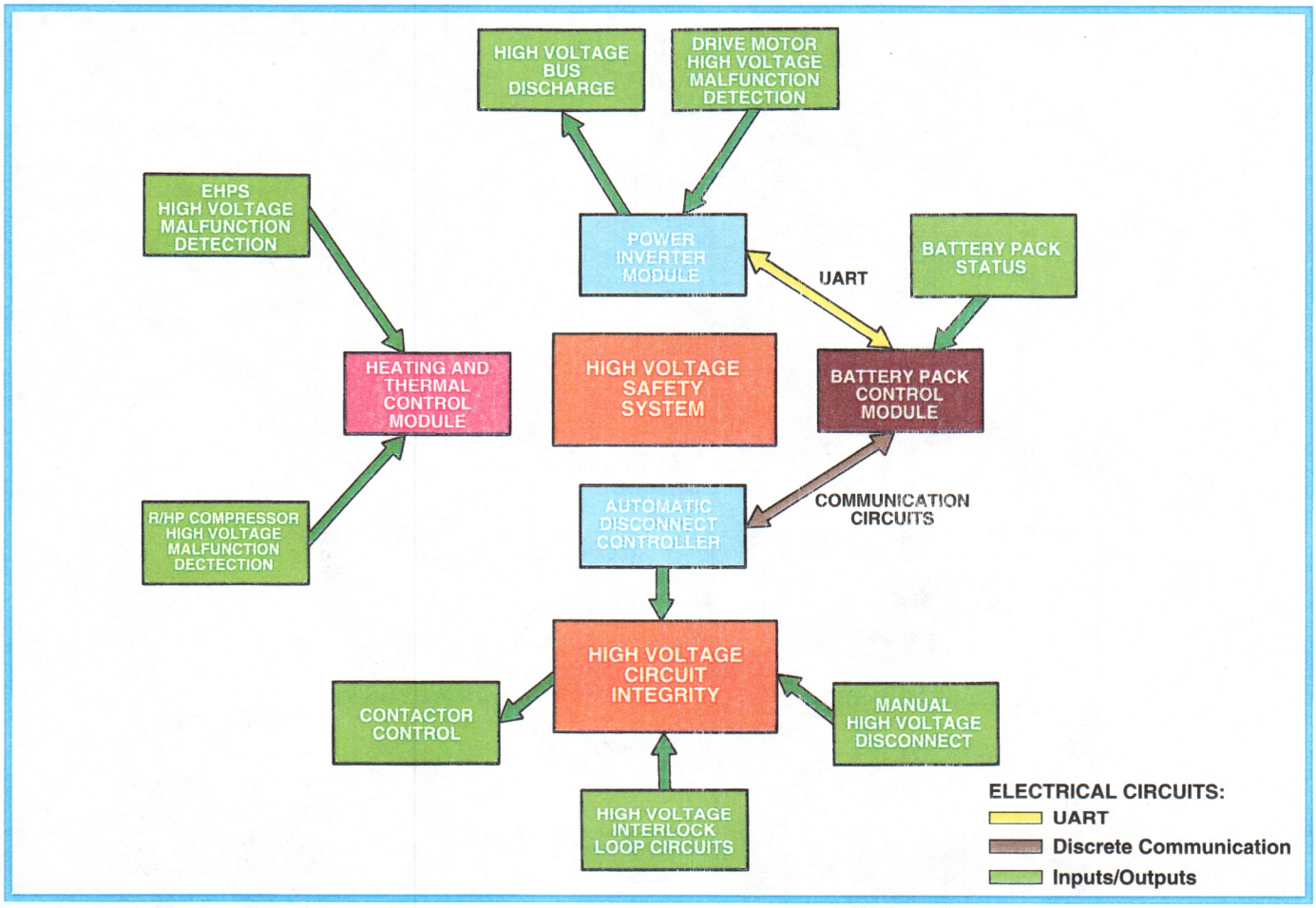


Figure 3-1, High Voltage Safety System Diagram

Automatic High Voltage Disconnect System

The automatic high voltage disconnect system has the following components (see Figure 3-2):

- Automatic Disconnect Controller
- Contactors (2)
- Power Inverter Module (PIM)
- Heating and Thermal Control Module (HTCM)
- Battery Pack Control Module (BPCM)
- High Voltage Interlock Loop (HVIL) circuits

The automatic high voltage disconnect system is responsible for monitoring the integrity of the high voltage system outside of the battery pack. The main controller of the system is the Automatic Disconnect (AD) controller. The AD controller contains circuitry that monitors the high voltage circuits for the following malfunctions:

- Disconnected high voltage connectors
- Open or shorted high voltage circuits
- Chassis isolation faults
- Insufficient battery pack voltage

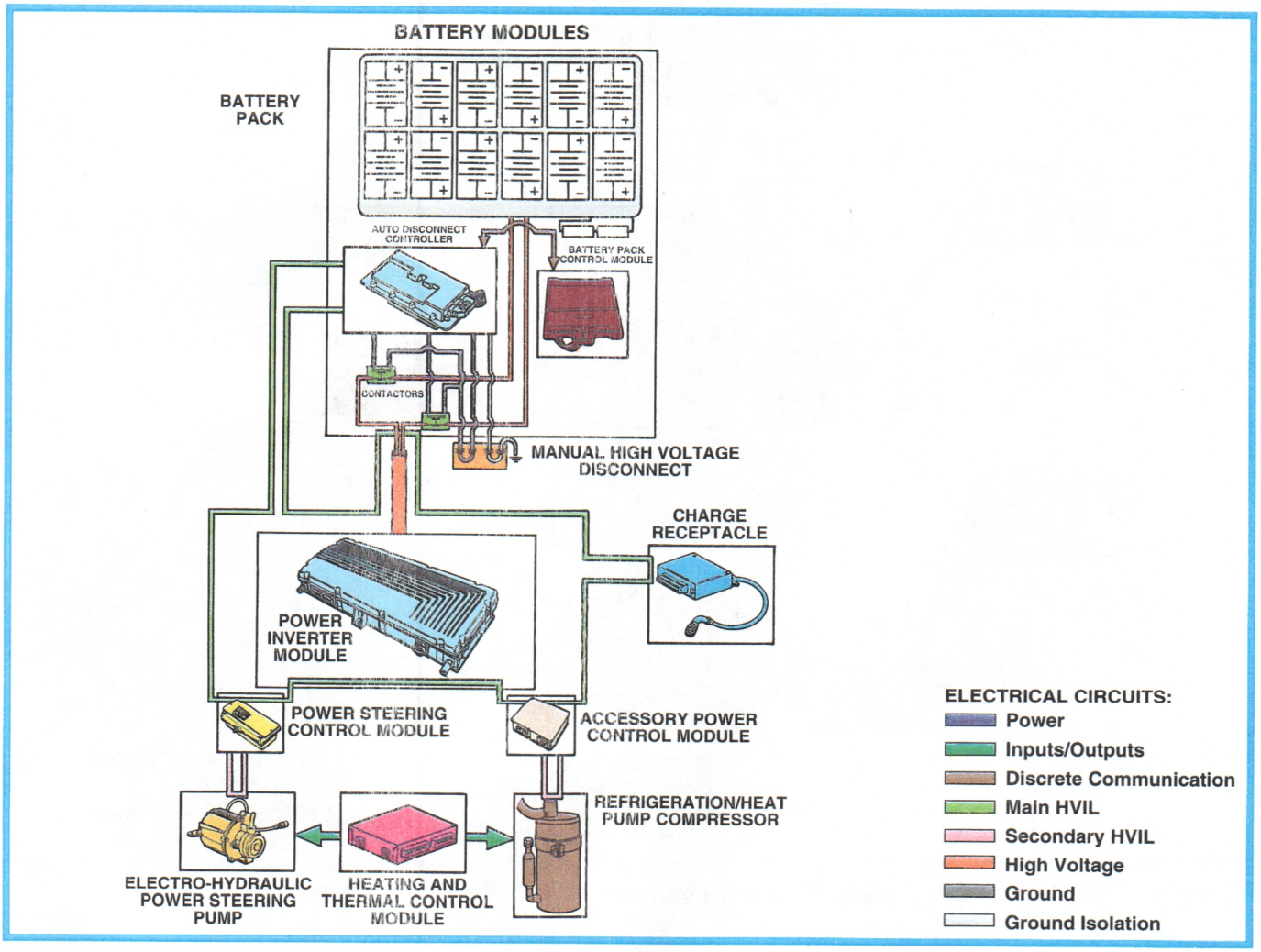


Figure 3-2, Automatic High Voltage Disconnect Schematic

The Automatic Disconnect controller receives operational voltage from the high voltage battery pack (refer to Figure 3-3). The AD controller receives this power from circuits connected to the contactors. This provides the AD controller with 320 volts. The AD controller steps-down this voltage to 12-14 volts. The AD controller also receives a 12 volt wake-up circuit from the Battery Pack Control Module (BPCM). If the battery pack has insufficient voltage prior to propulsion the AD controller will open the contactors.

When malfunctions are detected, the AD controller can use the contactors to disconnect the high voltage source in the battery pack from the high voltage circuits outside the battery pack. The contactors are high voltage relays. The AD controller uses one contactor to control the negative high voltage circuit and a second contactor to control the positive high voltage circuit.

The AD controller provides both the power and ground to the contactor coils (refer to Figure 3-3). The contactors are normally open relays; however, during normal operation the AD controller commands the contactors closed. The AD controller will only open the contactors when a malfunction is detected or the manual high voltage disconnect connector is removed. The AD controller can also control the contactors independently during pre-charging.

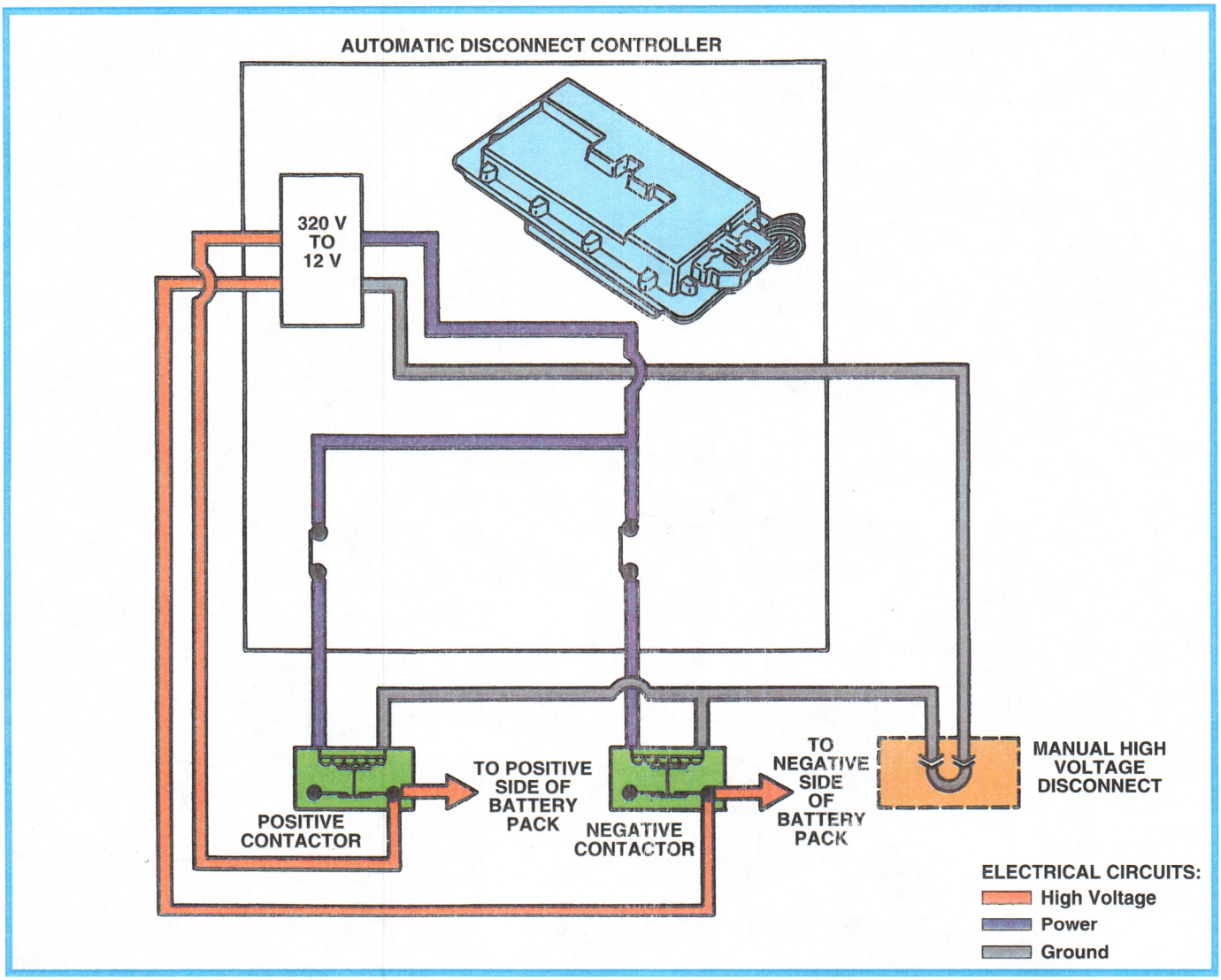


Figure 3-3, Contactor Operation

High Voltage Interlock Loop (HVIL)

The High Voltage Interlock Loop (HVIL) circuits are used by controllers to determine if the connectors of the high voltage circuits are connected. When a connector or an HVIL circuit is open, a controller will detect the loss of continuity. The HVIL circuits follow all high voltage circuits outside the battery pack. The HVIL circuits are divided into the main HVIL circuit and the secondary HVIL circuits.

The AD controller monitors the main HVIL circuit. The AD controller provides 7.9 to 10.6 volts (measured voltage will be 3.2 to 7.3 volts) to the main HVIL circuit and monitors the return voltage. If the AD controller does not receive a return voltage, the AD controller will open the contactors. The main HVIL circuit passes through the following components (refer to Fig 3-4):

- Power Inverter Module (PIM)
- Accessory Power Control Module (APCM)
- Power Steering Control Module (PSCM)
- Drive Motor Unit (DMU)
- Charge Receptacle

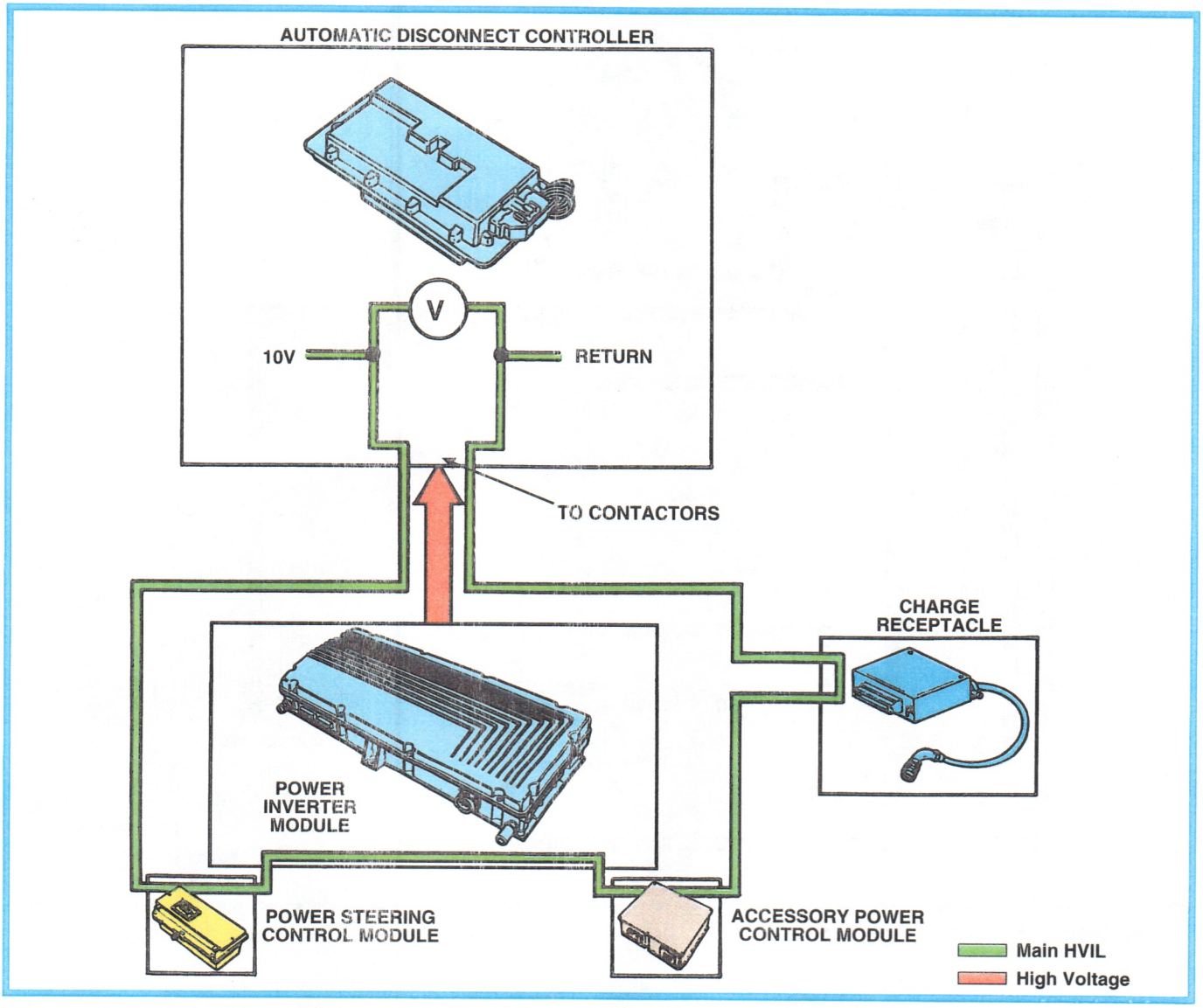


Figure 3-4, Main High Voltage Interlock Loop Circuit

The secondary HVIL circuits follow the high voltage circuits to the Refrigeration/Heat Pump (R/HP) compressor and the Electro-Hydraulic Power Steering (EHPS) pump (refer to Figure 3-5). The R/HP compressor HVIL circuit is monitored by the APCM. The APCM prevents R/HP compressor operation when continuity is lost in the compressor HVIL circuit. Continuity will be lost if the compressor connector is removed or if the HVIL circuit breaker inside the compressor is open due to overheating.

The EHPS pump HVIL circuit is monitored by the PSCM. The PSCM prevents EHPS pump operation when continuity is lost in the pump HVIL circuit. Continuity will be lost if the pump connector is removed or if the HVIL circuit breaker inside the pump is open due to overheating.

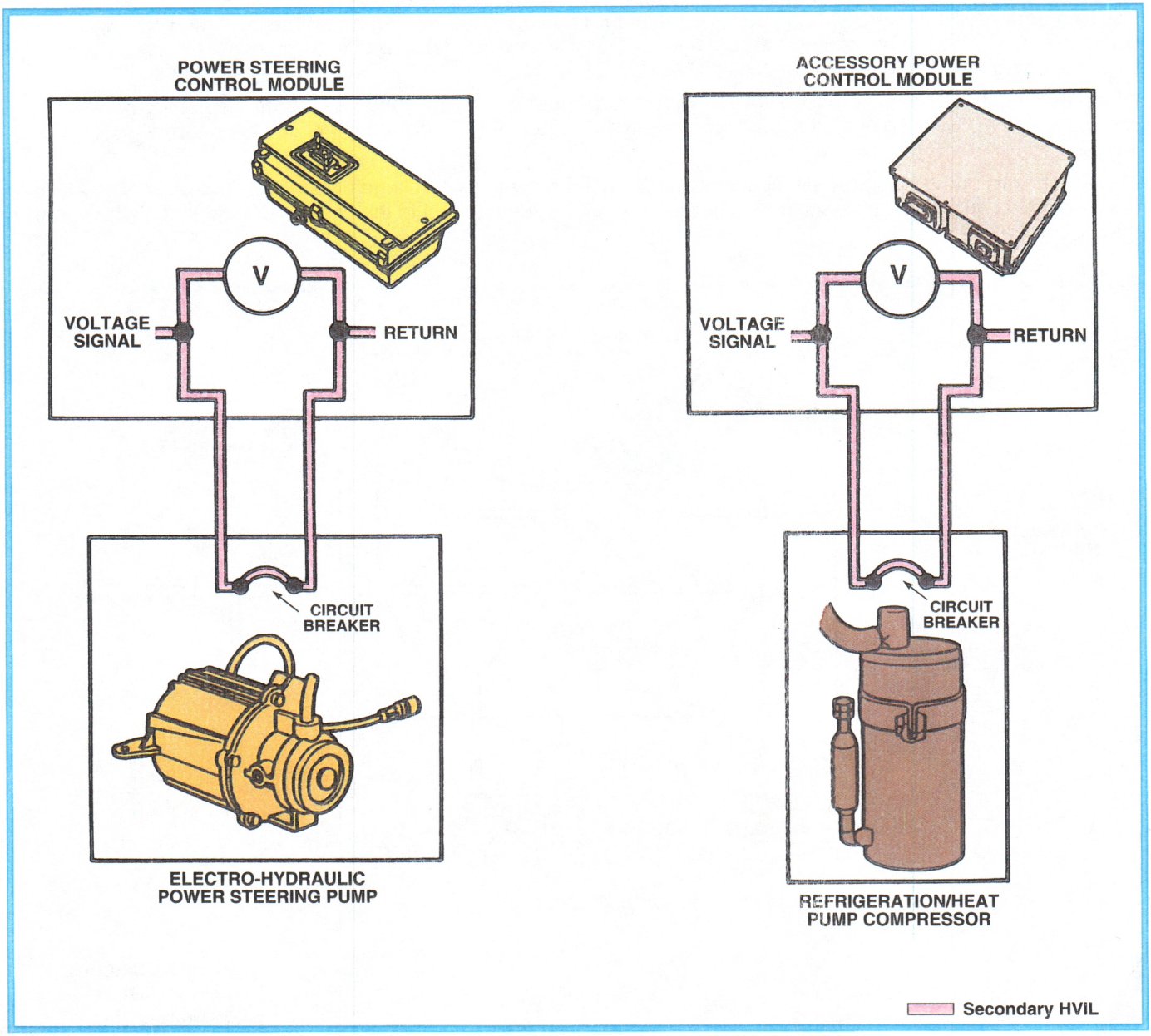


Figure 3-5, Secondary High Voltage Interlock Loop Circuit

High Voltage Chassis Isolation

The high voltage circuits are isolated from the chassis of the truck. The Automatic Disconnect controller monitors the chassis ground isolation circuit to determine if the high voltage circuit is shorted to the chassis ground (isolation fault). The AD controller can locate an isolation fault by measuring the voltage from both contactors to chassis ground (refer to Figure 3-6). During normal operation, there should not be measured voltage since the chassis ground is isolated from both the negative and positive high voltage circuits.

If, for example, the positive side of the high voltage circuit is shorted to chassis ground, the AD will measure high voltage between the chassis ground isolation circuit and the negative contactor. The AD controller will report this to the BPCM (on the status line circuits), and the BPCM will command AD controller operation based on vehicle speed and time parameters. If the BPCM determines that vehicle operation is within the parameters, the BPCM will command the AD controller to open the contactors. The AD controller must receive a command from the BPCM before opening the contactors for an isolation fault.

If both the negative and positive high voltage circuits are shorted to ground, the fuse inside the battery pack will open. The AD will also open the contactors when both sides of the high voltage circuit are shorted to chassis ground.

The AD chassis ground isolation circuit passes through the manual high voltage disconnect connector. The AD can monitor the integrity of the chassis ground isolation circuit by comparing it to the chassis ground that it shares with the BPCM.

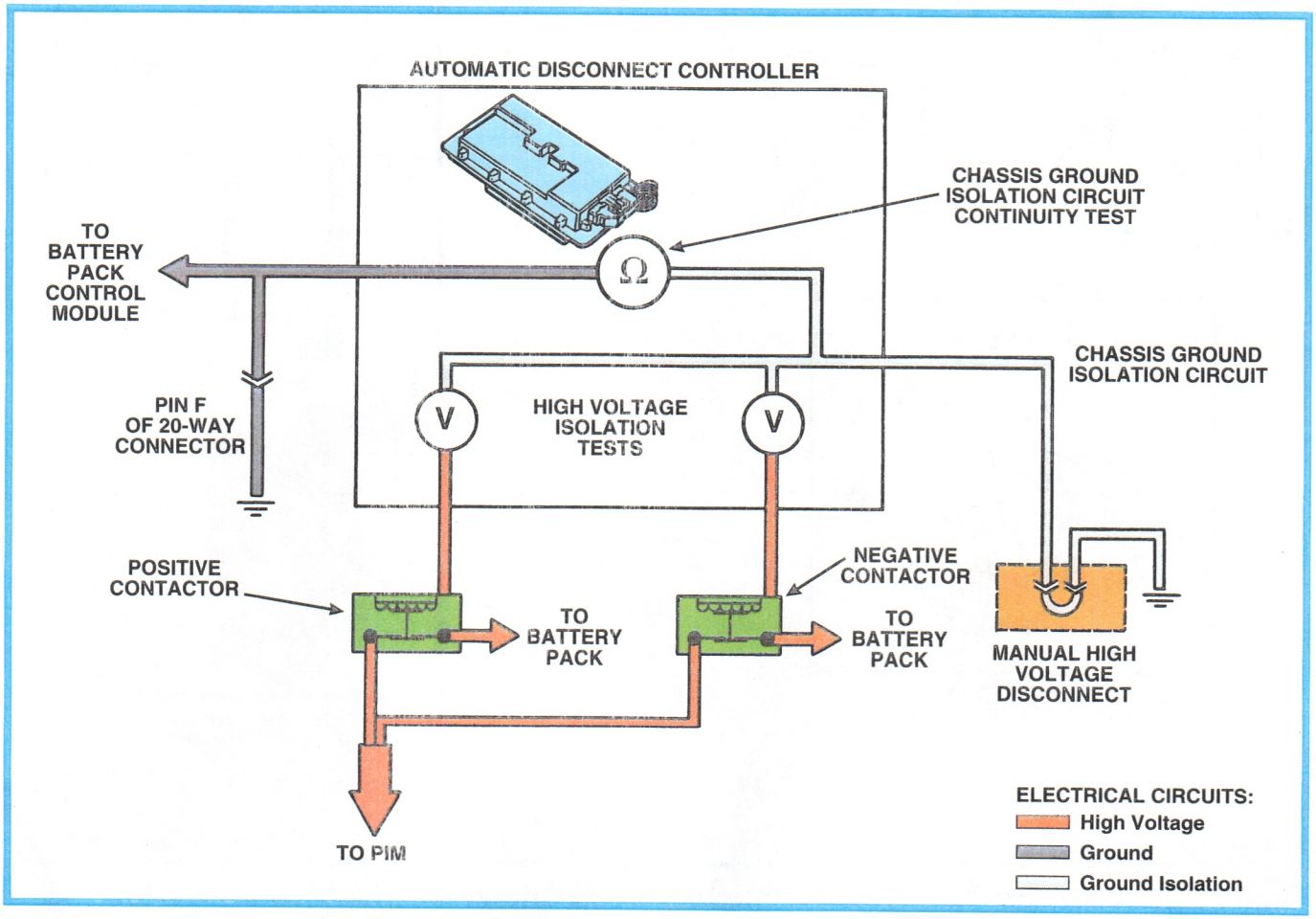


Figure 3-6, Chassis Ground Isolation Circuit

The AD controller can effectively detect direct current isolation faults. However, it cannot as effectively detect Alternating Current (AC) isolation faults. AC isolation faults are diagnosed by the PIM and HTCM. The PIM monitors the drive motor for AC isolation faults (refer to Figure 3-7). If one or more of the drive motor phases is shorted to the drive motor unit case, the PIM will disable propulsion. This will eliminate the shorted voltage to the chassis ground.

The HTCM monitors both the EHPS pump and R/HP compressor for AC isolation faults (refer to Figure 3-8). The HTCM has circuits connected to the cases of both the EHPS pump and R/HP compressor. These circuits allow the HTCM to detect AC isolation faults in these components.

If one or more of the AC phases of the EHPS pump is shorted to its case, the HTCM will detect the fault. The HTCM will request, on the UART data line, the PIM to disable the EHPS pump if an isolation fault is detected. This will eliminate the shorted voltage to the chassis ground.

If one or more of the AC phases of the R/HP compressor is shorted to its case, the HTCM will detect the fault. The HTCM will disable the R/HP compressor if an isolation fault is detected. This will eliminate the shorted voltage to the chassis ground.

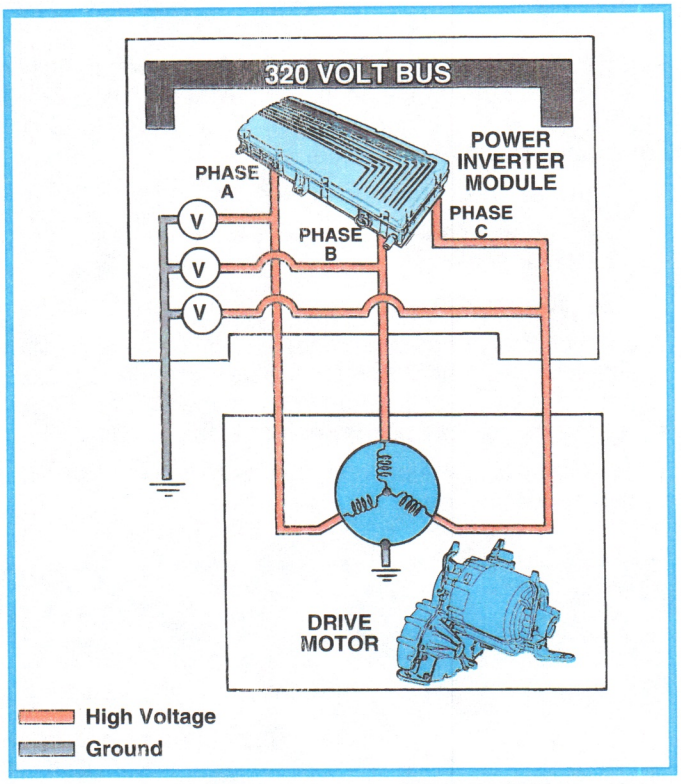


Figure 3-7, Drive Motor Isolation

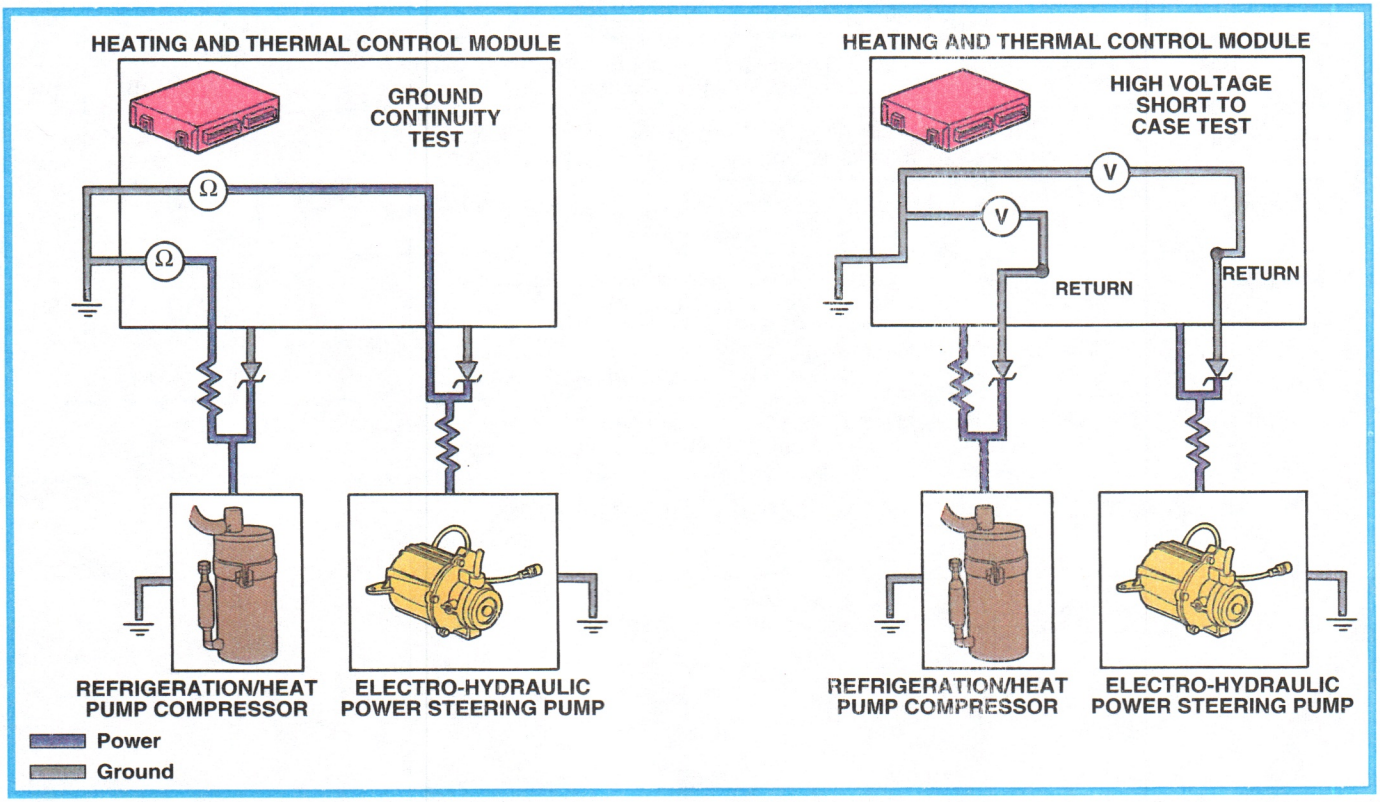


Figure 3-8, EHPS or Compressor Isolation

Automatic Disconnect and Battery Pack Control Module Communication

The Battery Pack Control Module (BPCM) has the ability to command the AD controller to open the contactors. The BPCM has a command circuit to the AD controller. Certain battery module malfunctions detected by the BPCM will result in the BPCM requesting the AD controller to open the contactors. The BPCM provides the following commands to the AD controller:

- **Normal:** this command allows the AD controller to operate normally.
- **Inhibit:** this command allows the AD controller to open the contactors for any fault other than an isolation fault or severe over or under voltage condition.
- **Disconnect:** this commands the AD controller to open the contactors.

The AD controller has three communication circuits (status lines) to the BPCM (refer to Figure 3-10). The BPCM provides each circuit with 5 volts. The AD controller can pull the circuits low to provide the BPCM with status signals. Based on the voltage signals, the BPCM can determine the operational status of the AD controller. The status messages can be viewed using the TECH 2. Refer to Figure 3-9 for the Status line messages.

The AD controller will provide signals on the status lines only after it receives either ignition voltage or a BPCM vehicle wake-up signal.

STATUS	DESCRIPTION	STATUS LINE VOLTAGE		
		1 (A)	2 (B)	3 (C)
Normal	Contactors are closed and high voltage is at the PIM.	0V	0V	0V
Fail	Pre-charge fault, pre-charge did not occur within the time parameter. Contactors are open.	0V	0V	5V
Commanded:	Contactors are open due to a BPCM command.	0V	5V	0V
Loop:	The AD Controller detected a fault in the HVIL circuit. The AD controller is waiting for a command from the BPCM.	5V	5V	0V
Pre-charge:	Pre-charge is in process. The positive contactor is open and the negative contactor is closed.	5V	0V	0V
Low Voltage:	The AD Controller has detected low battery pack voltage. The AD controller is waiting for a command from the BPCM.	5V	0V	5V
Ground:	The AD Controller has detected a shift or loss of ground. Contactors are open.	5V	5V	0V
Isolation:	The AD Controller has detected a chassis isolation fault. The AD controller is waiting for a command from the BPCM.	5V	5V	5V
PS Fail:	The BPCM detects a failure in the power supply of the AD Controller. No signals present. Contactor status unknown.	N/A		
Invalid:	The BPCM is unable to determine the status based on the status line signals. Invalid signal combination. Contactor status unknown.	N/A		

Figure 3-9, Automatic Disconnect Controller Status Lines

The BPCM monitors the status lines to determine the status of the contactors and to receive feedback on AD controller diagnostics. Certain diagnostics performed by the AD controller require BPCM input before the AD controller can open the contactors. The AD controller can not open the contactors for isolation faults or severe battery pack under or over voltage condition without a command from the BPCM.

For these conditions, the BPCM monitors the vehicle speed and also the selected transmission range. The BPCM will only command the AD controller to open the contactors (Disconnect command) if the vehicle speed is below 1 km/h for 3 minutes or if the vehicle is in Park for 10 seconds. If these parameters are not met, the BPCM will provide the AD controller with the Inhibit command. This will prevent the AD controller from opening the contactors under these conditions.

The AD controller also provides the BPCM with a power supply status circuit (refer to Figure 3-10). This circuit allows the BPCM to determine if the AD controller has sufficient voltage to communicate on the status lines. This circuit is necessary since the AD controller receives its power from the battery pack.

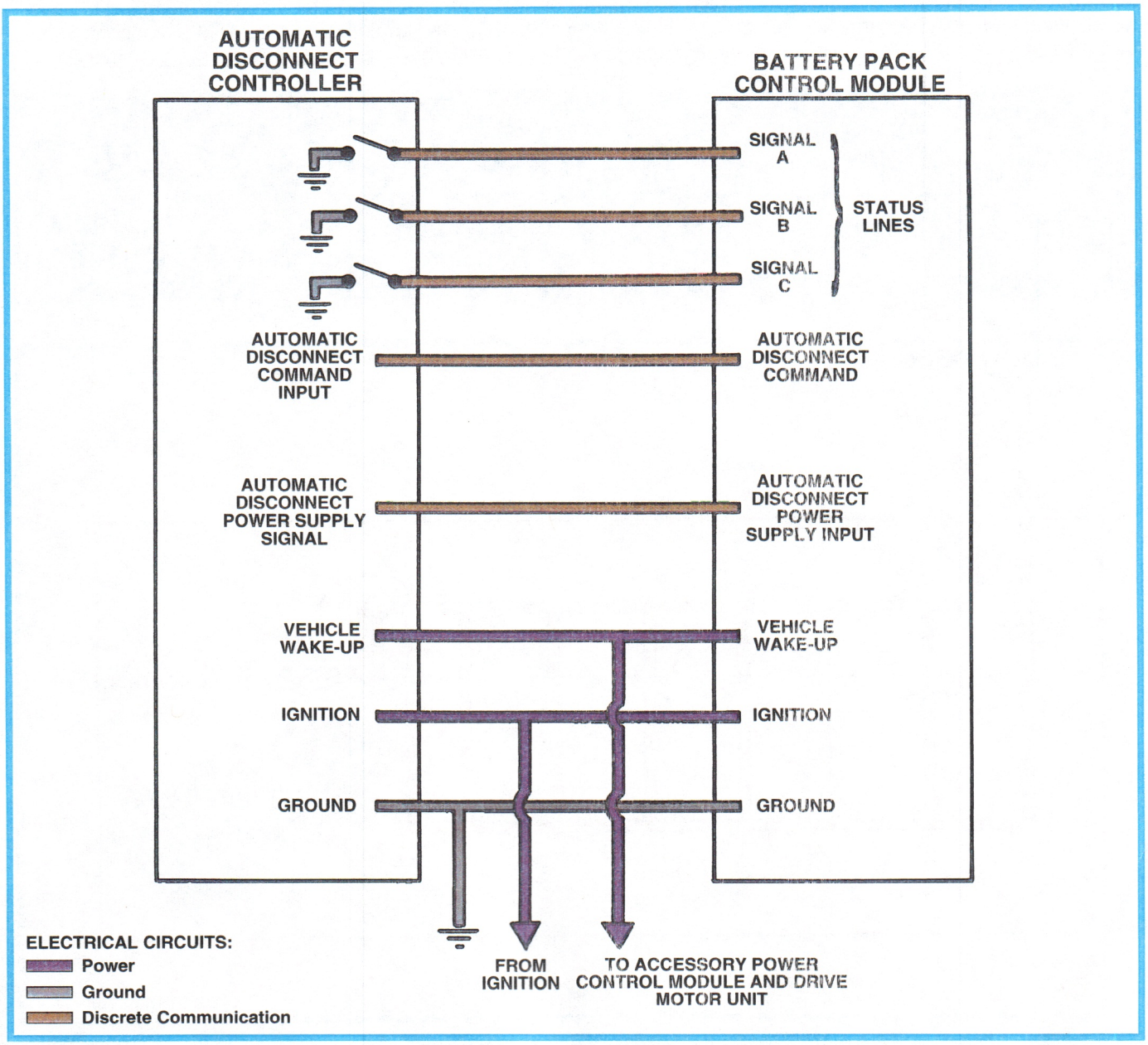


Figure 3-10, Automatic Disconnect Controller Status Line Circuits

High Voltage Discharging Inside the Power Inverter Module

When the contactors are opened, the high voltage source inside the battery pack is disconnected from all high voltage circuits outside the battery pack. However, there is residual high voltage on the high voltage bus inside the PIM. The PIM has internal circuitry that is designed to discharge the high voltage bus. This circuitry allows the high voltage stored in the high voltage bus capacitors to safely discharge in 250 milliseconds.

The PIM controls the discharge circuit by using a high voltage transistor and a resistor. When the PIM is discharging the high voltage bus, it discharges the bus capacitors by directing current flow through the transistor to the resistor (see Figure 3-11).

During normal operation, the PIM can determine when the AD controller is opening the contactors. The BPCM provides the PIM with the AD controller status line signals on the UART data line. The PIM will discharge the high voltage bus based on this information.

The discharge circuitry also prevents the high voltage PIM terminals from remaining "hot" if high voltage connectors are removed without removing the manual high voltage disconnect. The transistor in the circuit is designed to allow the resulting high voltage surge to pass through it, resulting in the bus discharging. Since the PIM is not controlling the transistor, the current flow will permanently damage the transistor. If this occurs, the PIM must be replaced.

– CAUTION –

NEVER REMOVE A HIGH VOLTAGE CONNECTOR WITHOUT DISCONNECTING THE MANUAL HIGH VOLTAGE DISCONNECT. FAILURE TO REMOVE THE MANUAL HIGH VOLTAGE DISCONNECT COULD RESULT IN COMPONENT DAMAGE AND POSSIBLE PERSONAL INJURY. ALSO, NEVER ASSUME THE PIM HAS DISCHARGED THE BUS. ALWAYS USE A METER TO VERIFY THE STATUS OF THE PIM HIGH VOLTAGE BUS.

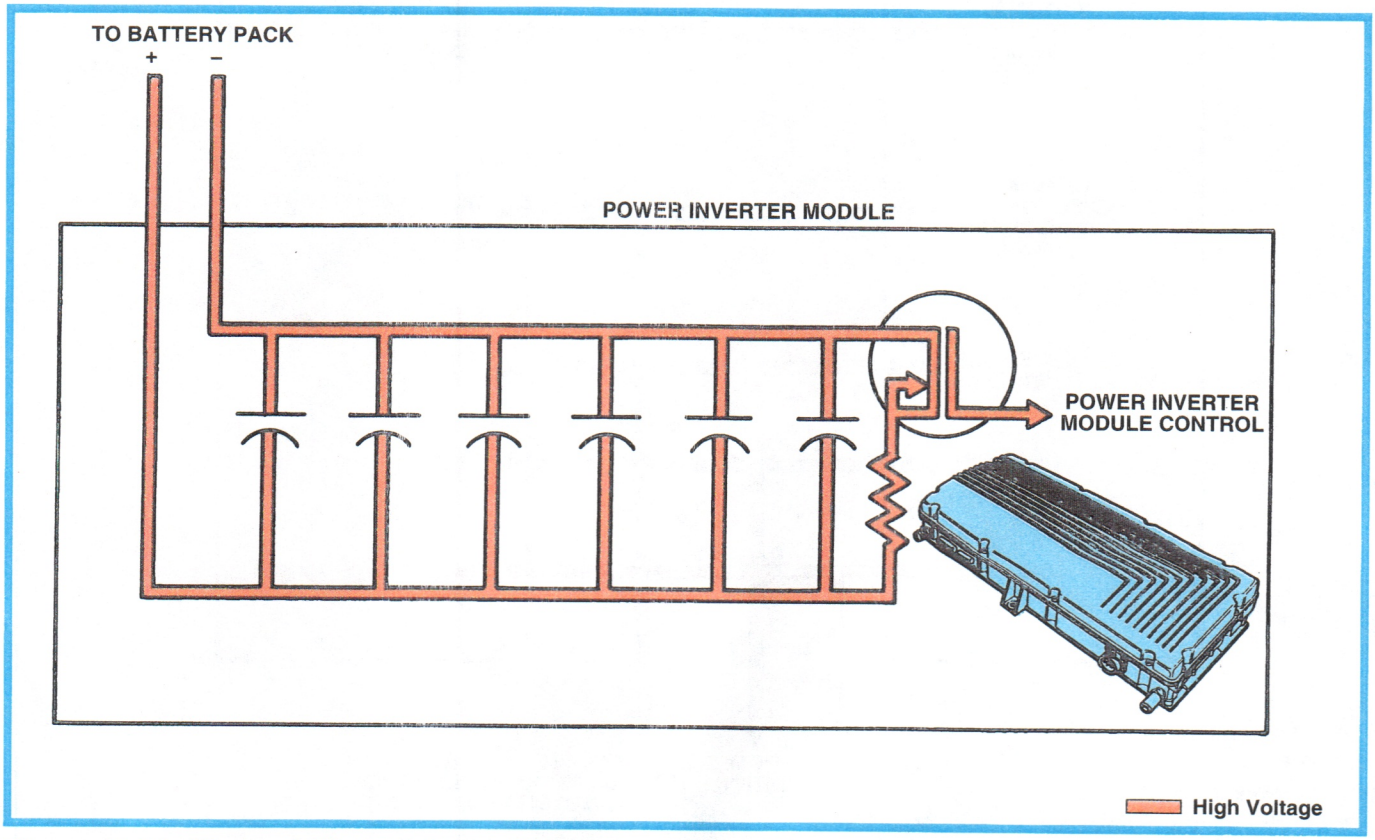


Figure 3-11, Manual High Voltage Disconnect Location

Pre-Charging (Pre-Conditioning)

If the contactors have been opened, the Automatic Disconnect controller must slowly charge the high voltage system outside of the battery pack prior to charging or propulsion. This function is called pre-charging or pre-conditioning. The manual high voltage disconnect (service disconnect) must be installed for pre-charging to occur.

Pre-charging will occur anytime that one or both contactors have been opened. During pre-charging, the AD controller places resistance in the high voltage circuit. This resistance allows the PIM to slowly charge the high voltage bus.

Prior to pre-charging, the AD controller uses the pre-charge sense circuits to determine the status of the high voltage circuits outside the battery pack. The pre-charge sense circuits are connected to the external battery pack harness side of the contactors (refer to Figure 3-12). If the AD controller detects a malfunction, it will prevent pre-charging from occurring.

The AD controller slowly energizes the high voltage system by closing the negative contactor and placing a resistance circuit in the positive side of the high voltage circuit (refer to Figure 3-13). The resistance circuit bypasses the positive contactor which is open. This allows the PIM to prepare the high voltage system for the high current available from the battery pack. Once the system is charged, the positive contactor is closed and the resistance is removed.

The AD controller monitors the current flow through the pre-charge circuit to determine when pre-charging is completed. If the high voltage bus capacitors do not reach 90% of battery pack voltage within 10 seconds, the AD controller will signal the BPCM that a fault is detected. The BPCM will then store a DTC for the fault.

The pre-charge resistors are located outside the AD controller near the positive contactor.

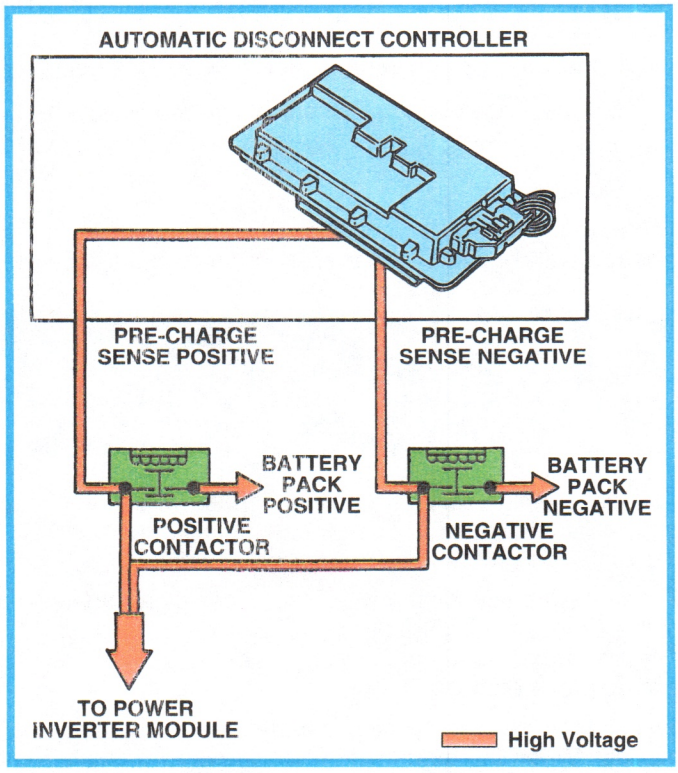


Figure 3-12, Pre-Charge Sense Circuits

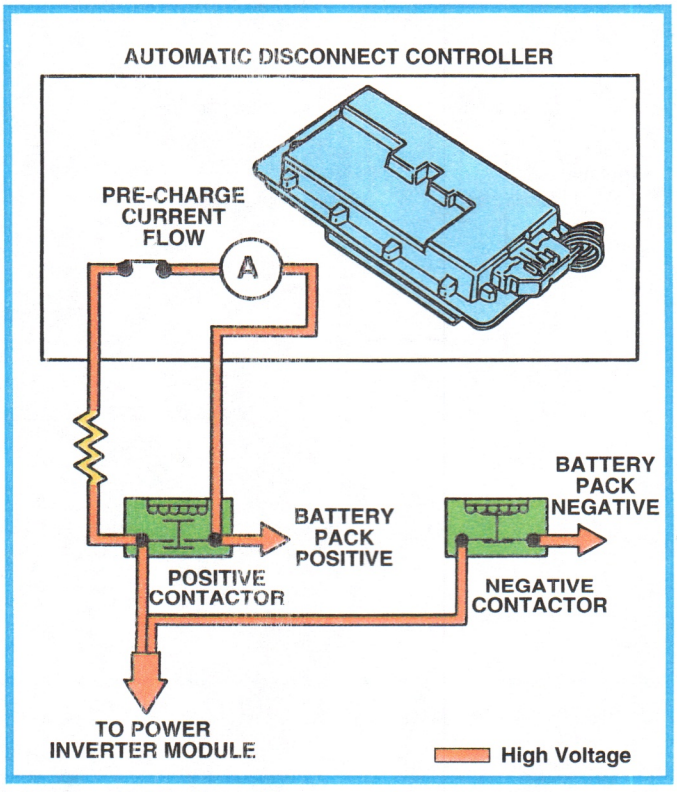


Figure 3-13, Pre-Charge Circuit

Manual High Voltage Disconnect System

The following are the components of the manual high voltage disconnect system:

- Manual High Voltage Disconnect (service disconnect)
- Automatic Disconnect Controller
- Contactors

The manual high voltage disconnect system allows the high voltage system outside of the battery pack to be discharged. The high voltage disconnect is located on the left side of the engine compartment bulkhead.

— CAUTION —
NEVER REMOVE THE MANUAL HIGH VOLTAGE DISCONNECT DURING CHARGING. COMPONENT DAMAGE WILL OCCUR.

The manual high voltage disconnect has two circuits (refer to Figure 3-14). One circuit is the AD controller chassis ground isolation circuit. The other circuit is the ground for both contactors. When the manual high voltage disconnect is removed, it creates two conditions.

The first condition is the loss of the chassis ground isolation circuit. When the AD controller monitors the status of the circuit, it will detect a loss of continuity. This condition will result in the AD controller opening both contactors. The second condition is the loss of ground to the contactor coils. The loss of coil ground will result in the contactors opening.

The second condition provides a method to discharge the high voltage circuits that is independent of a control module. When the manual high voltage disconnect is removed, the AD controller cannot close the contactors.

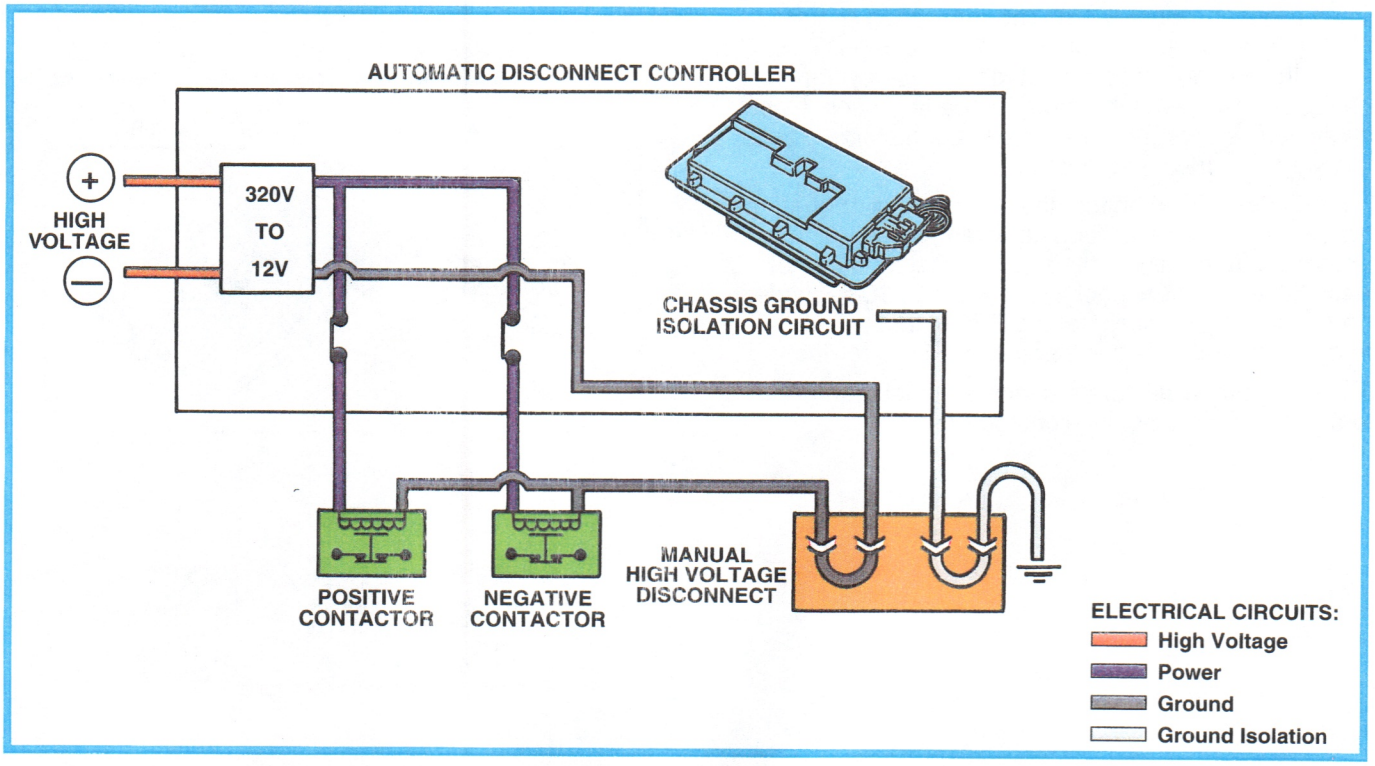


Figure 3-14, Manual High Voltage Disconnect Circuit

Notes

Notes

4. Battery Pack Control System

Overview

The battery pack control system is controlled by the Battery Pack Control Module (BPCM). The battery pack control system performs the following functions:

- Battery pack status monitoring:
  - Voltage (individual modules and battery pack)
  - State of Charge
- Battery pack temperature monitoring:
  - Battery Pack Inlet Air Temperature (BPIAT) Sensor
  - Battery Pack Temperature Sensors
  - Battery Pack Airflow Sensor
- Communication to transfer information between the following:
  - BPCM, Power Inverter Module and the Heating and Thermal Control Module (UART data line)
  - BPCM and Automatic Disconnect Controller (status lines and command circuit)
  - BPCM and Charge Receptacle (Class 2 data line)
- Discrete inputs to the I/P via the Body Control Interface Module

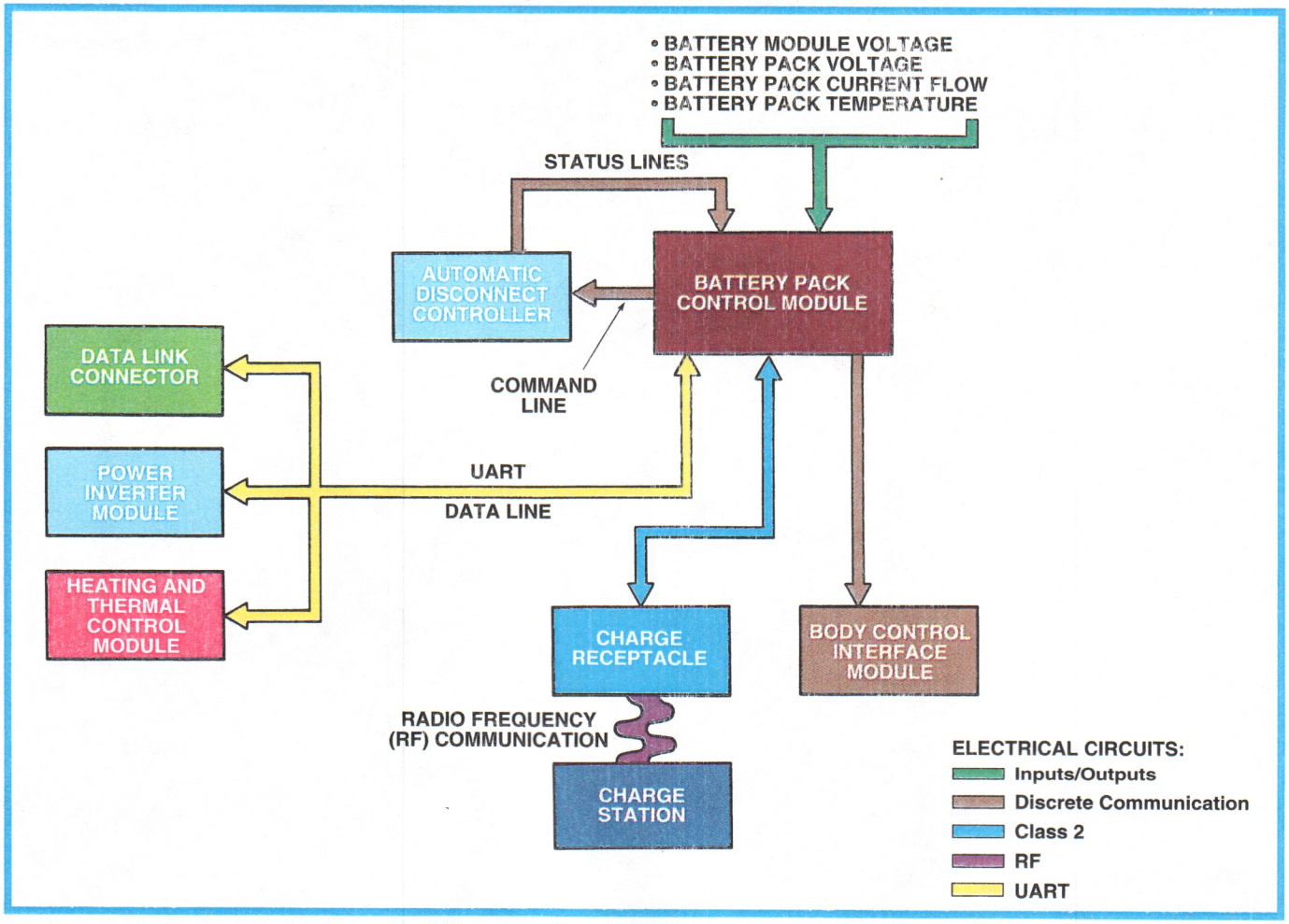


Figure 4-1, Battery Pack Control System Diagram

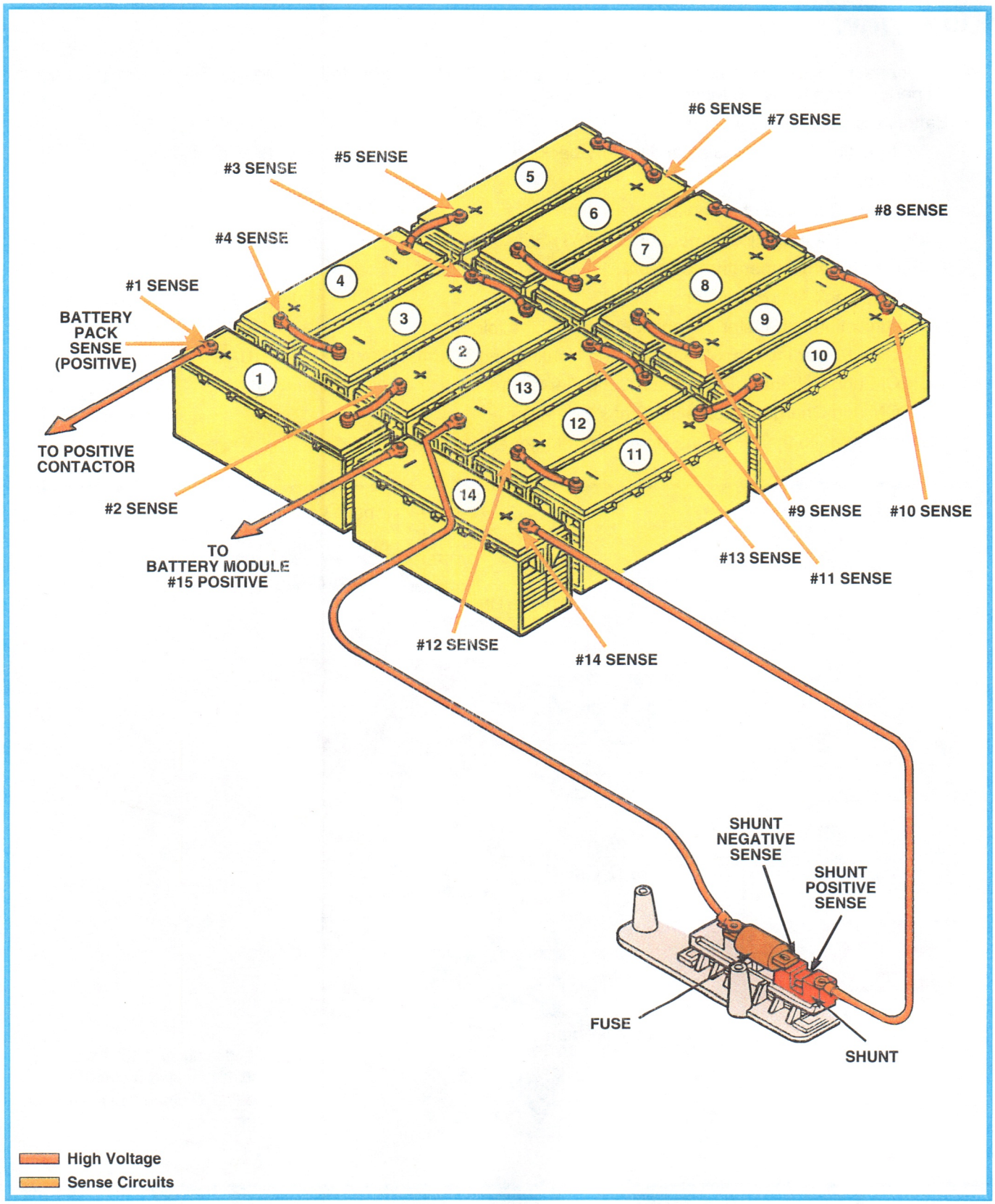


Figure 4-2, Battery Pack Lower Level Sense Circuits

Battery Pack Control Module

The Battery Pack Control Module (BPCM) monitors the battery pack operation. The BPCM monitors the following:

- Individual Battery Module Voltage
- Total Battery Pack Voltage
- Split Battery Pack Voltage
- Battery Pack Current Flow

Each battery module has one sense circuit connected to its positive terminal. Certain battery modules have multiple sense circuits (refer to Figure 4-2 and 4-3). Battery module #1 has two sense circuits connected to the positive terminal. One sense circuit is used for monitoring the #1 battery module voltage. The second circuit is used with a sense circuit connected to the negative terminal of the #26 battery module to determine the overall battery pack voltage.

Battery module #26 has three sense circuits. One sense circuit is connected to the positive terminal. Two sense circuits are connected to the negative terminal. One sense circuit on the negative terminal is used for monitoring the #26 battery module voltage. The second circuit on the negative terminal is used with a sense circuit connected to the positive terminal of the #1 battery module to determine the overall battery pack voltage.

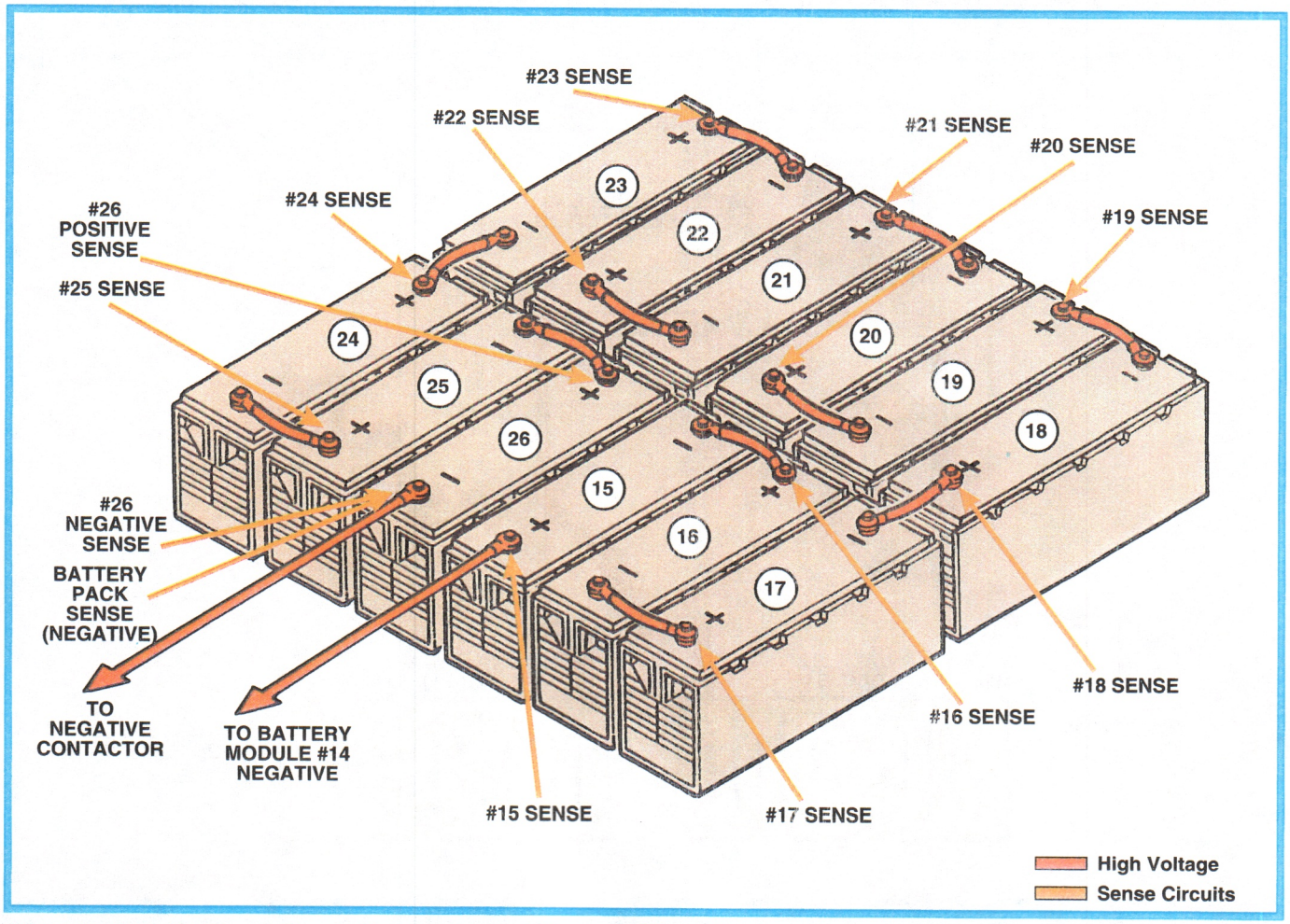


Figure 4-3, Battery Pack Upper Level Sense Circuits

4. Battery Pack Control System

Battery Module Voltage Monitoring

The BPCM monitors individual battery module voltage by using sense leads that are connected to the positive terminal of each battery module. To determine the voltage of a specific battery module, the BPCM uses the sensing circuit connected to the positive terminal of that battery module and the sensing circuit connected to the next battery module in the series circuit (refer to Figure 4-4). Since the battery modules are in series, the sensing circuit on the positive terminal can be used by the BPCM to monitor both the positive terminal of the specific battery module and also monitor the negative terminal of the next battery module in the series. The BPCM monitors each battery module and compares the measurement to BPCM parameters to determine the status of the battery module.

The BPCM monitors the battery modules for several different malfunctions. The BPCM testing is based on certain parameters (listed in the Diagnostic Trouble Code charts). The DTC will only set after the parameters are met. The battery modules are monitored for the following malfunctions:

- No Voltage: the battery module is less than 1 volt.
- Performance: the battery module voltage is 0.6 volt different from the average battery module.
- Out-of-Range: the battery module voltage is 1 volt different from the average battery module.
- Circuit Low: the battery module voltage is low as compared to the battery pack current flow.
- Circuit Very Low: the battery module voltage is very low as compared to the battery pack current flow.
- Over Voltage: the battery module voltage is higher than the BPCM parameter for battery modules.

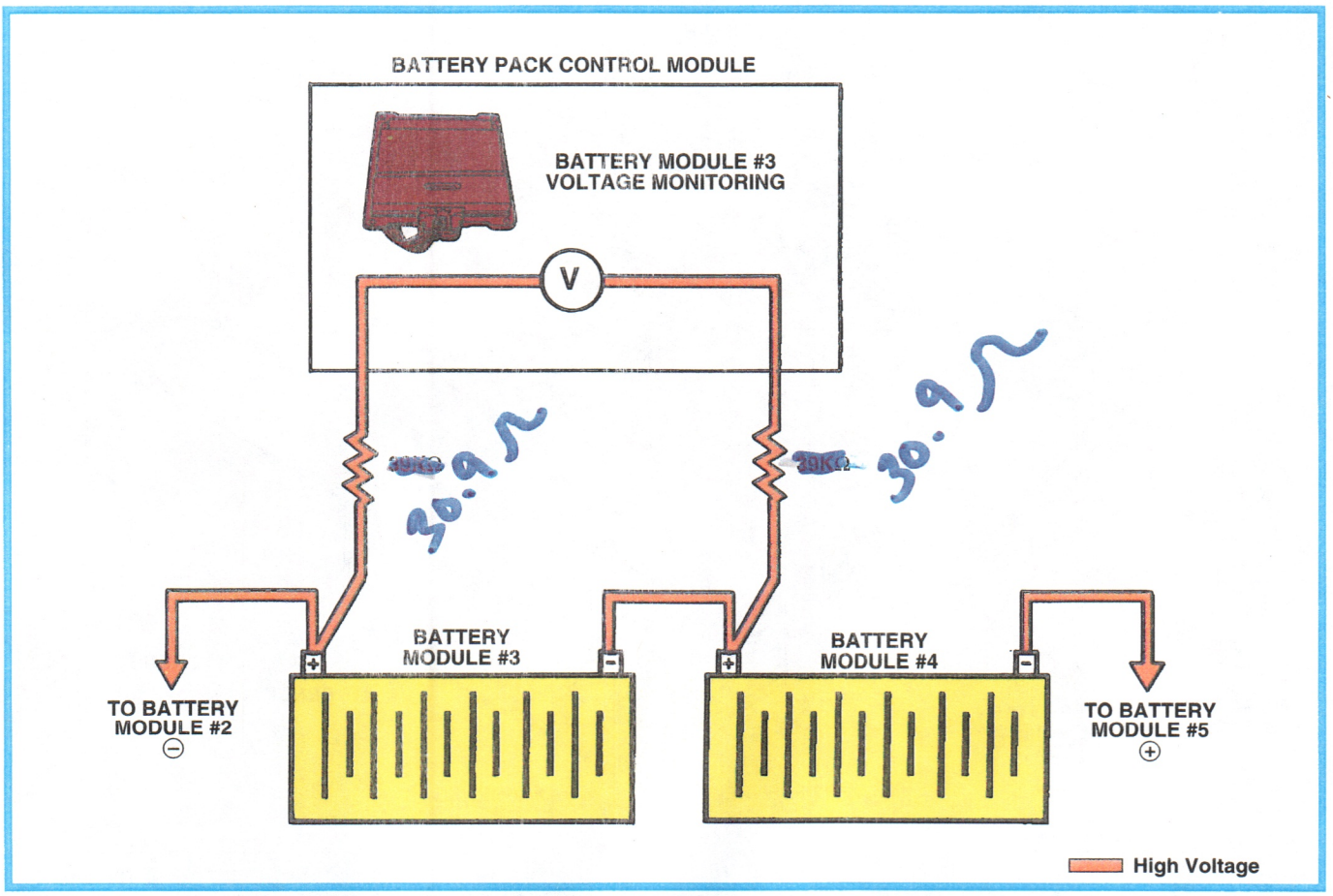


Figure 4-4, Battery Module Voltage Monitoring Circuit

Total Battery Pack Voltage Monitoring

The BPCM monitors the battery pack total voltage. To measure the total battery pack voltage, the BPCM uses the sense circuit connected to the positive terminal of battery module #1 and the sense circuit connected to the negative terminal of battery module #26 (refer to Figure 4-5). For certain tests, the BPCM monitors each half of the battery pack (battery modules 1-13 and 14-26). To measure each half of the battery pack, the BPCM uses the shunt low circuit and the appropriate battery module sense circuit.

The battery pack is monitored for the following voltage malfunctions:

- Battery Pack Voltage Out-of-Range: the battery pack voltage is outside of normal operating range.
- Battery Pack Voltage Performance: the battery pack voltage does not equal the sum of the individual modules.
- Battery Pack Low Voltage: the battery pack voltage is low as compared to the battery pack current flow.
- Battery Pack Extremely Low Voltage: the battery pack voltage is very low as compared to the battery pack current.
- Battery Pack Extreme Over Voltage: the battery pack voltage exceeds a BPCM parameter based on temperature.

The BPCM will set DTCs for the battery pack malfunctions if the parameters for the DTC are met.

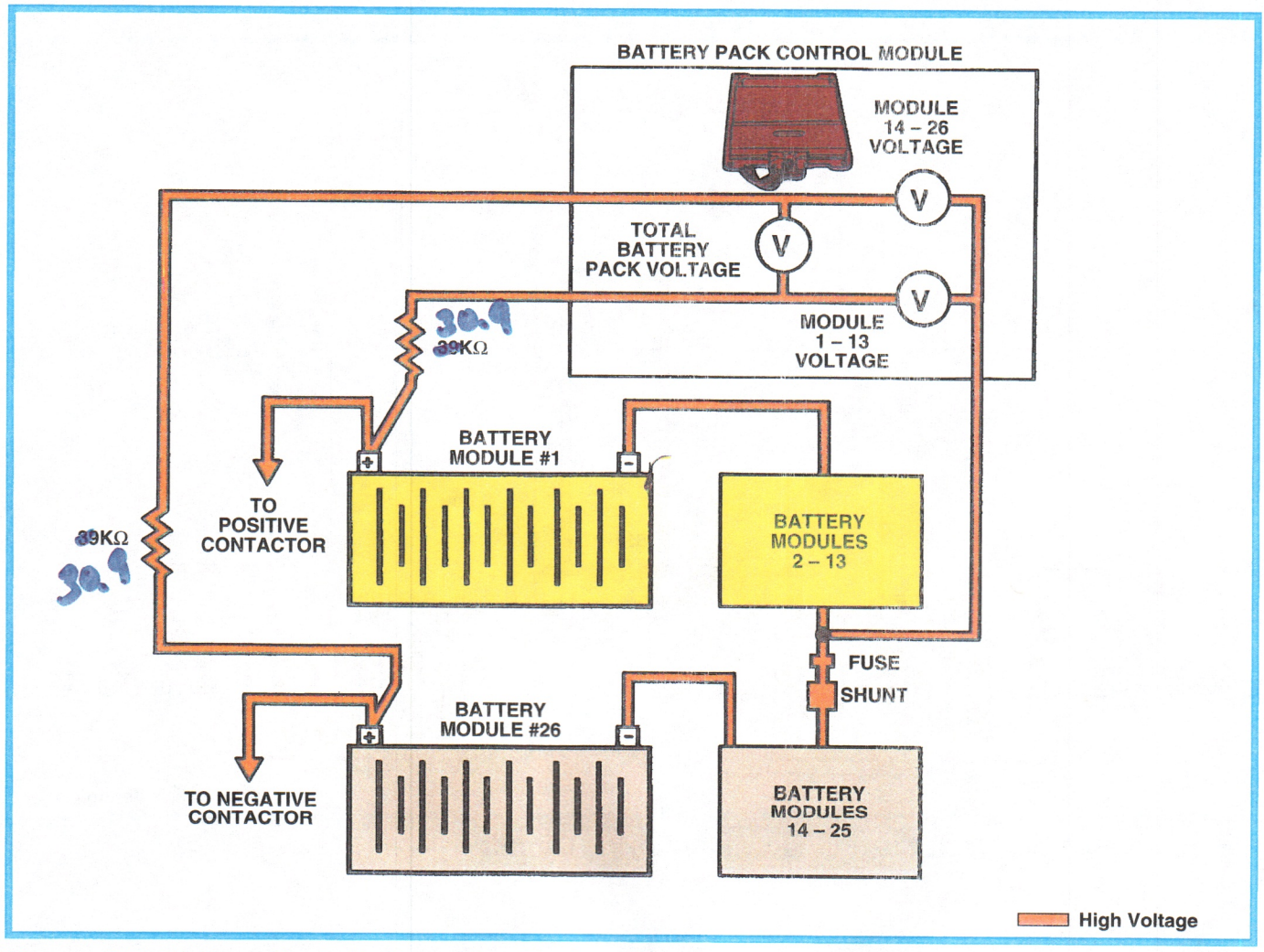


Figure 4-5, Battery Pack Voltage Monitoring Circuit

Battery Pack Current Flow Monitoring

The BPCM monitors the battery pack current flow to determine the amount of amperage leaving or entering the battery pack. This measurement is used with the information on battery pack temperature and voltage to determine the state-of-charge of the battery pack. The BPCM will disable propulsion when the battery pack state of charge falls below a certain parameter.

The BPCM uses a shunt to monitor battery pack state of charge. The shunt is located between battery modules #13 and #14 in the series circuit. The shunt is a precision resistor with very little resistance. The BPCM uses the shunt to electronically split the battery pack. The BPCM and shunt resistor circuit performs the same function as an ammeter (refer to Figure 4-6).

The BPCM monitors current flow to determine certain malfunctions and to disable propulsion when the state-of-charge falls below a BPCM parameter. The BPCM uses two different State-Of-Charge (SOC) calculations. The first calculation is the True State-Of-Charge (TSOC). This is the actual SOC of the battery pack. The second calculation is the User State-Of-Charge (USOC). This is the SOC that is displayed on the instrument panel gauge. The USOC is 15% lower than the TSOC. This is done to prevent the vehicle operator from discharging the battery pack to a point where the battery pack range could be permanently reduced.

The battery pack shunt is in series with a fuse. The fuse will split the battery pack voltage in half if there is excessive current flow. The fuse is primarily designed for high voltage component protection. The fuse will NOT provide protection from electrocution.

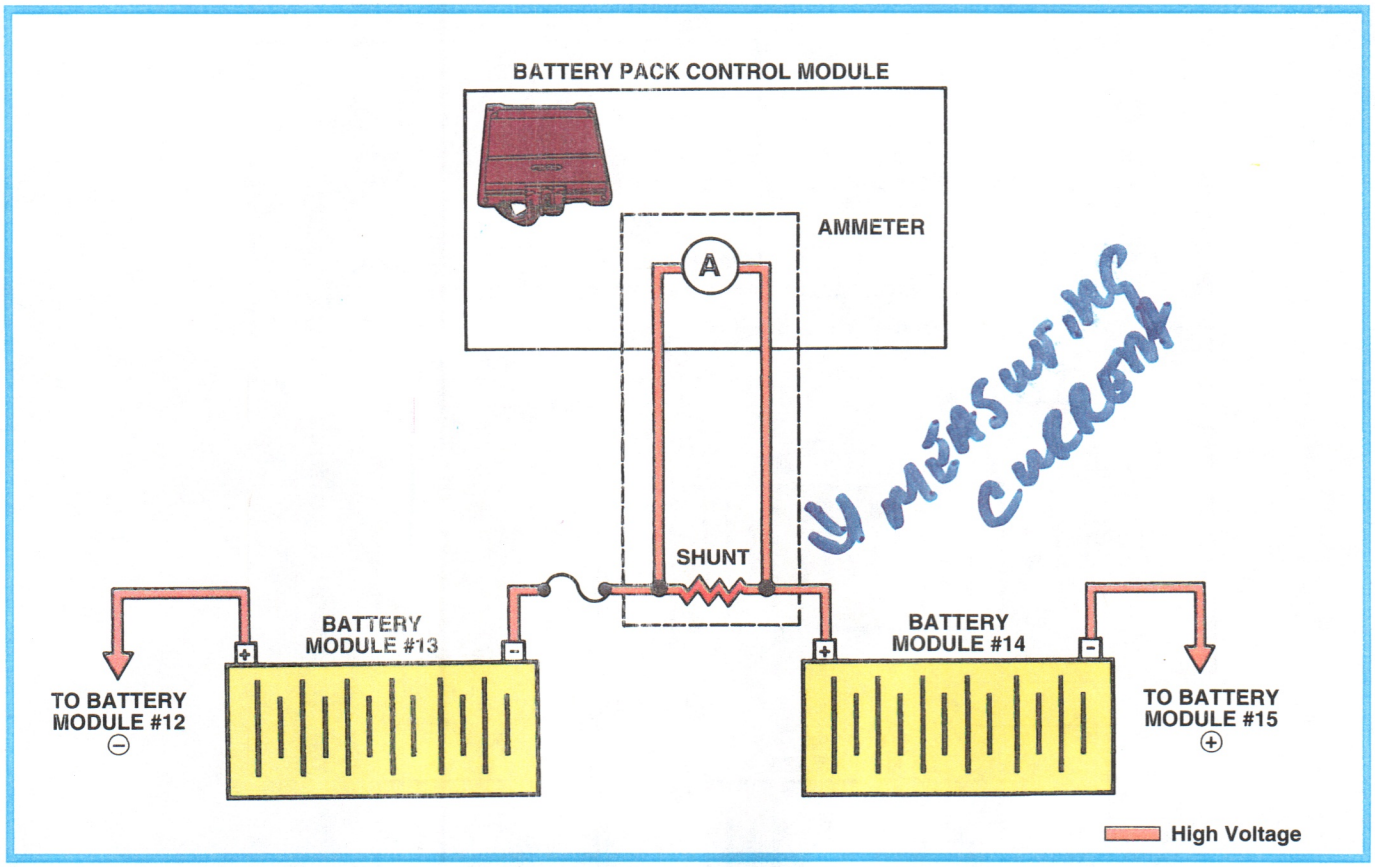


Figure 4-6, Battery Pack Current Flow Monitoring Circuit

Temperature Monitoring

The BPCM monitors the temperature of the battery pack to perform thermal management and to determine state-of-charge. The temperature of the battery pack can largely affect the capacity of the battery modules. This has a direct effect on the state-of-charge of the battery pack and vehicle range. To maintain the battery pack temperature in the normal operating range, the BPCM has the ability to request thermal management from the Heating and Thermal Control Module (HTCM). The BPCM can request cooling during charging and propulsion. Heating can only be requested during charging.

The BPCM determines the temperature of the battery pack based on the following sensors:

- Battery Pack Inlet Air Temperature (BPIAT) sensor
- Battery Pack Temperature sensors (6 sensors)

The BPCM uses the BPIAT sensor to determine the temperature of the air entering the battery pack. The six temperature sensors are used to determine the actual battery pack temperature. The sensors are located in both the upper and lower levels of the battery pack (refer to Figure 4-7). The sensors are mounted to specific battery modules. There are four sensors on the upper level and two sensors on the lower level of the battery pack.

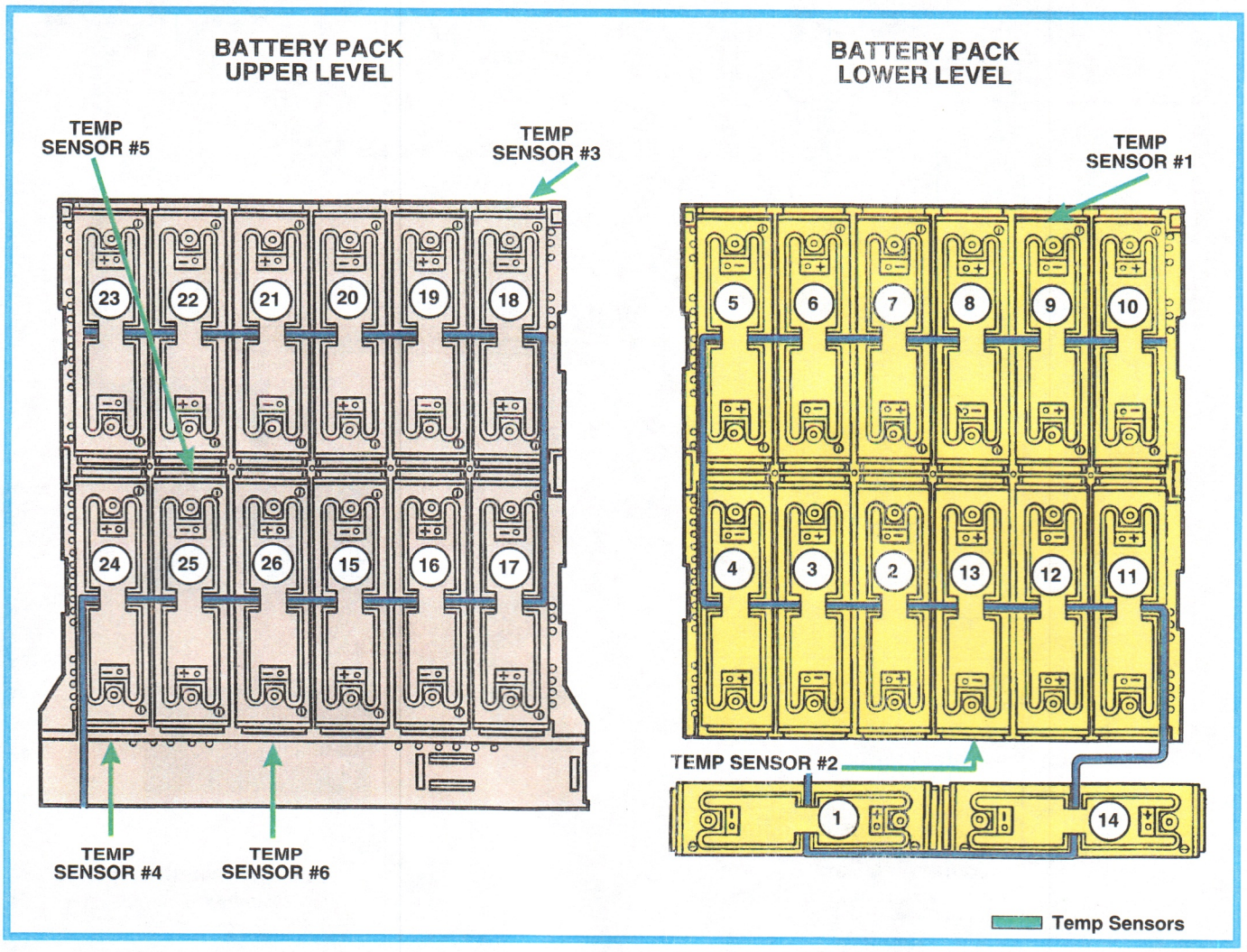
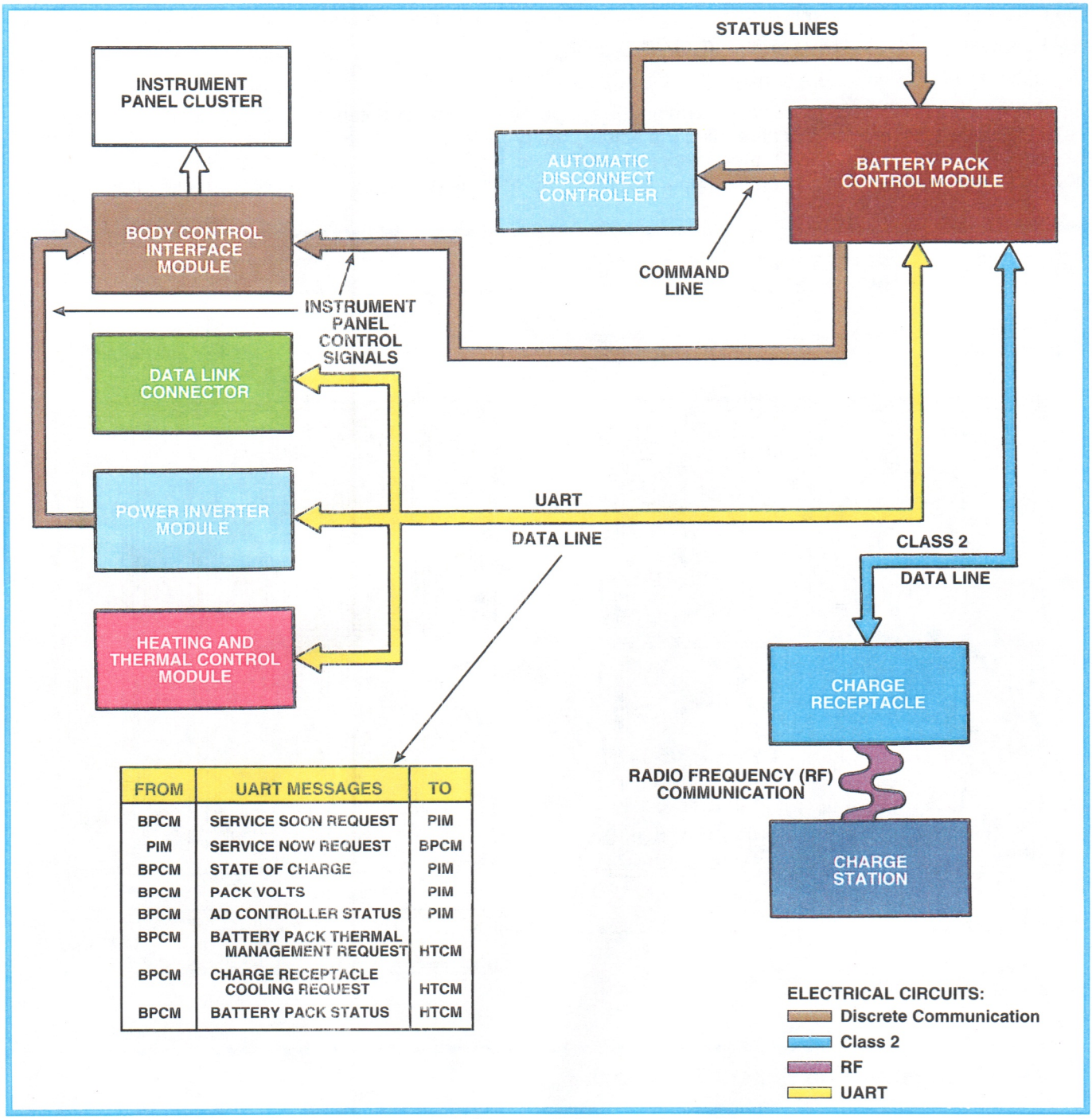


Figure 4-7, Temperature Sensor Locations

Battery Pack Control Module Communication

The Battery Pack Control Module (BPCM) must exchange information with other control modules. This information is transferred on either data communication lines or discrete communication circuits (refer to Figure 4-8). The BPCM uses two different data communication lines, Class 2 and UART. These communication lines can carry several different pieces of information. The BPCM also uses several discrete communication circuits. The discrete communication circuits can only provide one piece of information.



FROM	UART MESSAGES	TO
BPCM	SERVICE SOON REQUEST	PIM
PIM	SERVICE NOW REQUEST	BPCM
BPCM	STATE OF CHARGE	PIM
BPCM	PACK VOLTS	PIM
BPCM	AD CONTROLLER STATUS	PIM
BPCM	BATTERY PACK THERMAL MANAGEMENT REQUEST	HTCM
BPCM	CHARGE RECEPTACLE COOLING REQUEST	HTCM
BPCM	BATTERY PACK STATUS	HTCM

Figure 4-8, BPCM Communication Circuits

The BPCM uses the Class 2 data line to exchange information with the charge receptacle and Data Link Connector (DLC). The UART data line provides communication between the BPCM, PIM, HTCM and DLC. The following is some of the information related to the battery pack on the UART data communication line:

- Service Soon Request (from the BPCM or HTCM to the PIM)
- Service Now Request (from the PIM to the BPCM)
- Battery Pack Status (from the BPCM to the HTCM and PIM)
  - State-Of-Charge
  - Pack Voltage
  - Malfunctions
  - Automatic Disconnect Controller Status
- Battery Pack Thermal Management Request (from BPCM to HTCM)
- Charge Receptacle Cooling Request (from BPCM to HTCM)

The BPCM has discrete communication circuits with the Automatic Disconnect (AD) controller and the Body Control Interface Module (BCIM). The circuits between the AD controller and the BPCM provide the BPCM with AD controller status. The BPCM also has a command circuit to the AD controller to command specific AD controller operation.

The discrete communication circuits between the BPCM and BCIM allow the BPCM to provide the following information and commands to the BCIM for control of the instrument panel cluster (refer to Figure 4-9):

- Service Now Lamp Request
- Battery Life Lamp Request
- Power Use Gauge Signal

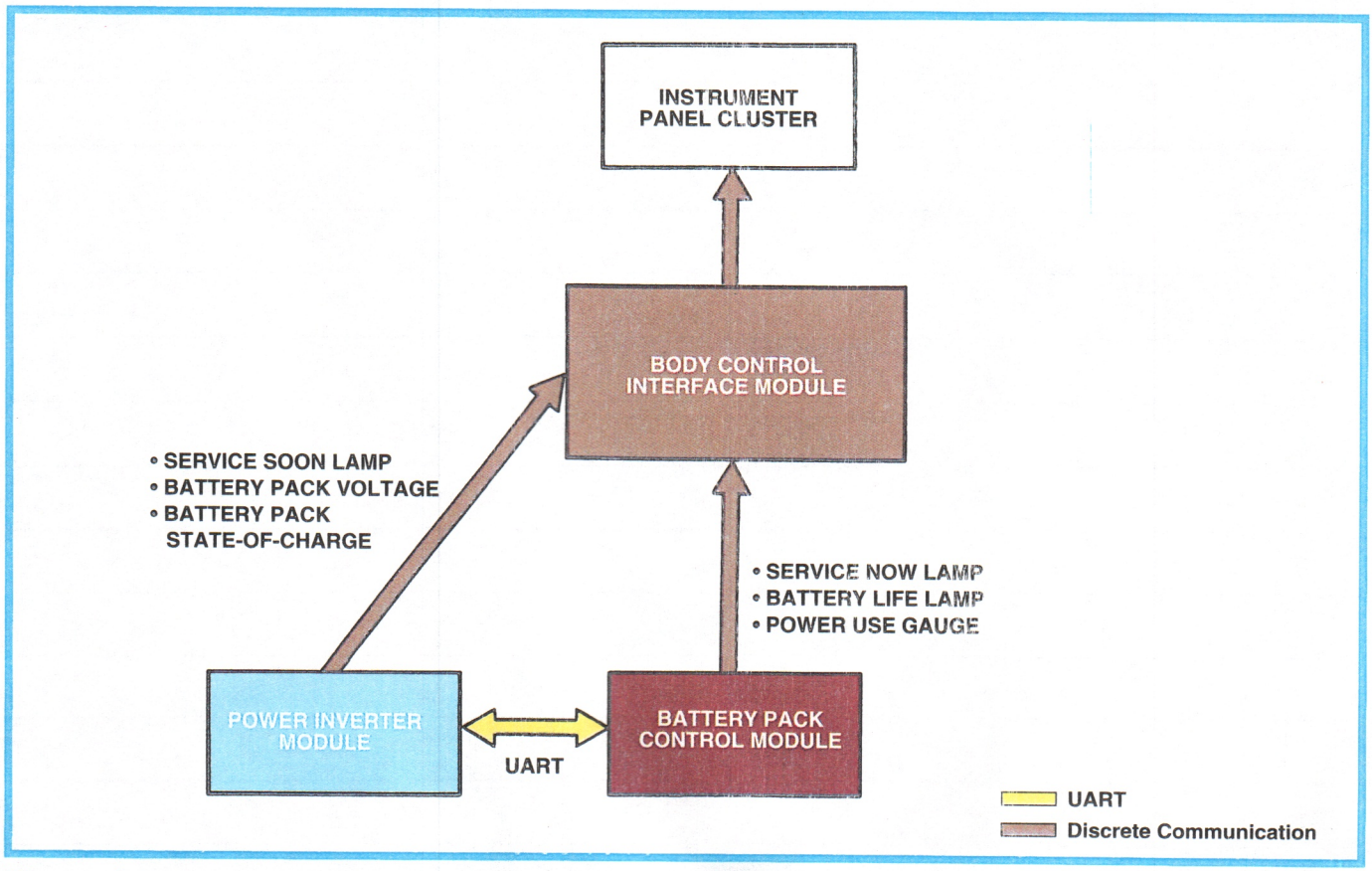


Figure 4-9, Communication Between the BCIM and BPCM

Notes

GENERAL MOTORS TRAINING MATERIALS

- Authentic GM Training Manuals & Instructor Materials
- Expertec Videotapes and Publications
- Hydra-matic Training Publications
- Training Simulators

These publications & videos offer thousands of facts on service procedures and how systems operate on GM cars and trucks.

Includes the same materials used in General Motors Training Centers for GM Dealer Technician Training.

Send today for your FREE GM training materials catalog.

General Motors Training Materials
Mascotech Mktg Service
1426 Pacific Drive • Auburn Hills, MI 48326
1-800-393-4831

For CPT materials, call 1-800-468-6657

MAY 1997

GENERAL MOTORS CORPORATION

PRINTED IN USA